AN ESTIMATE OF CARBON FOOTPRINT OF EKURHULENI HEALTH DISTRICT OFFICE AND PROVINCIAL CLINIC EMPLOYEES

by

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I declare that the above dissertation is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

.... ……………………….. 07 August 2017

Ibrahim O Elimi Date

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ABSTRACT

Climate change is regarded as the greatest threat facing the world today. The Intergovernmental Panel on Climate Change (IPCC) concluded that climate change is caused by human activities, as a result of greenhouse gases (GHGs) being emitted into the atmosphere. Scientific literature on the impact of climate change is well documented, especially for the health sector. The mission of the Gauteng Department of Health (GDoH) is to "contribute towards the reduction of the burden of diseases in all the communities in Gauteng". Ekurhuleni Health District is part of GDoH and shares a similar mission. However, this mission is under threat due to the direct and indirect impact of climate change on the public health sector. Therefore, it is essential for Ekurhuleni Health District and Provincial Clinics to take measures to reduce their contribution to climate change in the light of improving the health of their constituent. This study estimates the carbon footprint of the employees of Ekurhuleni Health District and Provincial Clinics and determines the knowledge and perception of climate change among managers and operational employees.

The methodologies of the Greenhouse Gas Protocol (GHGP) and the Department of Environmental Forestry and Rural Affairs (DEFRA) were used to quantify the carbon footprints of the employees of the Ekurhuleni Health District and Provincial Clinics. A content analysis was applied to determine the knowledge and perception of climate change. The study revealed that Scope 2, indirect emissions (electricity), accounts for 92% (35150 t CO_2e) of the total carbon footprints for the period of five years, 2010-2014. Scope 1, direct emission (vehicles), is responsible for 4% (1362 t CO_2e) and Scope 3, indirect emissions for ICT, for 2% (862 t CO_2e), office paper 1% (181 t CO_2e) and air conditioners 1% (458 t CO_2e). The majority of employees demonstrated basic knowledge of climate change. However, the concept of GHGs was unfamiliar to most of the employees. In terms of perceptions of climate change, the majority of employees were concerned about the future of the planet and climate change and believed that climate change will impact their job description.

The study recommends the following mitigation measures, among others, to reduce carbon footprints: (1) electrical vehicles; (2) substituting personal desktops with laptops; and (3) substituting HFC-23 air conditioner refrigerant with R410A. These recommendations have the potential to reduce the carbon emissions by 2445 t CO_2e for the period of five (5) years and save R7 875 089 from fuel and power consumption. Furthermore, the District Office and Provincial Clinics can generate a revenue of R293 400 by registering for a CMD project for five years or R1 173 600 for the duration of the project (20 years).

***Keywords*:** Carbon footprints; Climate change; Clinics; Ekurhuleni Health; Health impacts; Clean Development Mechanism; Gauteng Department of Health.

TABLE OF CONTENTS

LIST OF FIGURES

Figure

LIST OF TABLES

Table

LIST OF ABBREVIATIONS AND ACRONYMS

CDP:	Carbon Disclosure Project
CH_4:	Methane
CO_2:	Carbon Dioxide
CO_2e:	Carbon Dioxide Equivalent
CRU:	Climate Change Unit
CTL:	Coal to Liquid
DALYS:	Disability: Adjusted Life Years
DEA:	Department of Environmental Affairs
DEFRA:	Department of Environmental Forestry and Rural Affairs.
DoH:	Department of Health
EMM:	Ekurhuleni Metropolitan Municipality
GCM:	Global Climate Model
GDoH:	Gauteng Department of Health
GHG:	Greenhouse Gas
GHGP:	Greenhouse Gas Protocol
GHGs:	Greenhouse Gases
GWC:	Growth without Constrains
GWP:	Global Warming Potential
H_2O:	Water
HFC:	Hydrofluorocarbon
HFC:	Hydrofluorocarbons
ICT:	Information Communication Technology
IPCC:	Intergovernmental Panel on Climate Change
ISO:	International Standard Organisation
JSE:	Johannesburg Stock Exchange
LTAS:	Long-Term Adaptation Scenario
N_2O:	Nitrous Oxide
NEE:	Non-Energy Emissions
O_3:	Ozone
PFC:	Perfluorocarbons
RBS:	Required by Science
RCM:	Regional Climate Model
RCP:	Representative Control Pathway
RFV:	Rift Valley Fever
SAPS:	South Africa Police Services
SASSA:	South Africa Social Security Agency
SBT:	Scenario Building Team
SF6:	Sulphur Hexafluoride 6
t CO_2e:	Ton Carbon Dioxide Equivalent
UN:	United Nations
WBCSD:	World Business Council for Sustainable Development
WRI:	World Resource Institute

Chapter 1
INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

Climate change is considered the largest threat facing the world today (Goklany, 2009:69; Kumaresan, Narain & Sathiakumar, 2011:201; Bell, 2011:804; Regan, Owen, Bakewell, Jackson, De Sousa Peixoto & Griffiths, 2012:1). The Intergovernmental Panel on Climate Change (IPCC) has concluded that human activities are responsible for climate change by emitting greenhouse gases (GHGs) into the atmosphere (IPCC, 2014:4-5). The level of GHGs emissions has increased since the pre-industrial time (1970), for example: an increase of 1.3% annually from 1970 to 2000 and 2.2% increase annually from 2000 to 2010 (IPCC, 2014:4-5). The greenhouse gas effect occurs when the GHGs absorbs the longwave radiation (LWR) emitted by the earth and reflects some of the absorbed LWR back to earth, causing an increase in temperature (Cubasch, Wuebbles, Chen, Facchini, Frame, Mahowald & Winther , 2013:126).

Temperature is an important determinant in climate change (Chenkova & Nikolova, 2015:S381). Many countries worldwide are expressing increases in average temperatures, for example: Bulgaria (Chenkova & Nikolova, 2015:S381-S390), Sri Lanka (Silva & Sonnadara, 2016:75-84), China (Lin, Zhu, Wang, Gong & Zou, 2016:1-24) and Central America (Hidalgo, Amador, Alfaro & Quesada, 2013:94-112). African countries are also experiencing increased temperatures, such as Nigeria (Adakayi & Ishaya, 2016:220-227), Cameroon (Ngondjeb, 2013:85-94), Zimbabwe (Sango & Godwell, 2015:1-6) and South Africa (Kruger & Shongwe, 2004:1929-1945; Mackellar, New & Jack, 2014:1- 13).

Africa is considered the most vulnerable continent to climate change due to poor adaptive capabilities (Stringer, Dyer, Reed, Dougill, Twyman & Mkwambisi, 2009:1; Dennis & Dennis, 2012:417). The impact of climate change on food security are expected to reduce the yield production by 50% in 2020 (Boko, Niang, Nyong, Vogel, Githeko, Medany & Yanda, 2007:435). Some countries have already experienced drought and loss of livestock (Debay, 2010: 3) and other direct impacts of climate change, such as storms and floods (Patz, Grabow & Limaye, 2014:332).

Climate change has an impact on human health, such as: (1) an increase vector- borne diseases; (2) an increase food-borne and water-borne diseases; (3) an increase in deaths due to heat waves; and (4) a higher number of malnutrition cases (IPCC, 2014:69). The international community consisting of different countries reached consensus in the Paris Agreement to take measures to limit the global temperature to below 2^{o}C (Nandy, 2016:47). In the South African context, Mr. Thabo Mbeki, a former president of South Africa in 2004, announced that South Africa will implement measures to allow the greenhouse gases (GHGs) emissions to deviate by 34% in 2020 and 42% in 2025 below its "business as usual" trajectory (DEA, 2012:25). To date, the South African Government has introduced policies and guidelines to mitigate climate change, such as: (1) National Climate Change Response White Paper; (2) South Africa Carbon Tax; and (3) Long Term Adaptation Scenarios (DEA, 2013:8; National Treasury, 2013:7; Adeleke, Kiragu, Murombo & Stiftung, 2014:6).

In view of the negative impact of climate change, Ekurhuleni Health District, as an organ, stated that consideration should be given to its contribution to reducing GHG emissions for the purpose of improving the health of their constituent. Therefore, it is relevant and appropriate to make a contribution to this appeal.

1.2 PROBLEM STATEMENT

Human activities are responsible for climate change by emitting greenhouse gases (GHGs) (IPCC, 2014:4-5). The process of quantification of greenhouse gas (GHG) emissions by person, organisation, process or activities is called carbon footprint (Rossi, Bonamente, Nicolini, Anderini & Cotana, 2016:97). Various studies at an international level have been conducted to quantify the carbon footprints of products and services, for example: carbon footprints of Laptops (Liu, Yang, Lu & Zhang, 2016:674-680); the carbon footprint of milk (Batalla, Knudsen, Mogensen, Hierro, Pinto & Hermansen, 2015:121-129); public procurement in a food industry (Cerutti, Contu, Ardente, Donno & Beccaro, 2016:82-93); sugar production (Garcia, Garcia-Treviño, Aguilar-Rivera & Armendáriz, 2016:2632-2641); and the textile industry (Wang, Wang, Liu, Du, Ding, Jia, Yan & Wu, 2015:464- 475; Yan, Wang, Ding, Zhang, Wu, Wang, Liu, Du, Zhang & Zhao, 2016:119-125).

Many companies and organisations have started voluntary calculations and to report their carbon footprint worldwide, especially in collaboration with the Carbon Disclosure Project (CDP). CDP is a non- profit organisation that works with companies worldwide to address and tackle climate change issues (CDP, 2016). In the South African context, numerous companies are voluntarily reporting their carbon emissions to the CDP.

Many of these companies are listed on the Johannesburg Stock Exchange (JSE). According to the 2015 CDP South African summary Report (2015:2), 79% of the top one hundred (100) JSE listed companies reported their carbon footprint emissions. The reporting of carbon footprints from state institutions based on literature search, showed one study (Smith, 2011:1-98) quantifying the carbon emissions of the South African Police Services (SAPS). The literature review offered limited information on carbon emissions of state institutions, hence it is essential for government institutions, especially the Department of Health (DoH), to establish a platform for the voluntary calculation and reporting of their carbon footprint. Therefore, this study attempts to estimate the carbon footprints associated with Ekurhuleni Health District office and Provincial Clinic employees and to determine the perceptions of climate change among managers and operations employees.

1.3 JUSTIFICATION

The South African Government mandate in the National Climate Change Response White Paper is for each sector and subsector to set emission reduction targets and formulate a plan to achieve those set targets. It is essential for all spheres of government to plan climate change response strategies and set an example for the private sector. Before any emission reduction targets are set, it is essential that the current status quo baseline is known by means of carbon footprint quantification.

The mission of Gauteng Department of Health (GDoH), among others, is to "contribute towards the reduction of the burden of diseases in all the communities in Gauteng" (Department of Health, 2016). Ekurhuleni Health District is part of the Gauteng Department of Health (GDoH) and therefore shares a similar mission. However, this mission is under threat due to the direct (storms, drought, floods) and indirect impact (increased food-borne and water-borne diseases, malnutrition and death due to heat waves) of climate change on the public health sector (IPCC, 2014:69; Patz *et al*., 2014:332). It is essential for Ekurhuleni Health District to take measures to reduce their contribution to climate change by quantifying their carbon footprint emissions. This study will:

- Serve as a baseline assessment of the amount of carbon dioxide equivalent emissions emitted by government employees;
- Identify challenging areas with the highest emissions;
- Formulate potential mitigation strategies to reduce the emissions;
- Create an awareness on carbon footprints of government employees;
- Educate employees on different methodologies of reducing their carbon footprints.

1.4 AIM AND OBJECTIVES

The aim of the study was to estimate the carbon footprints of Ekurhuleni Health District and Provincial Clinic employees and to determine the knowledge and perception of climate change among managers and operational employees.

In order to meet the aim of the study, the following three objectives are investigated:

1. To estimate the carbon dioxide equivalent emissions of Ekurhuleni Health District and provincial clinics employees by:
   - Determining the carbon footprint of government fleet vehicles;
   - Determining the carbon footprint of electricity consumption of facilities;
   - Determining the carbon footprints of printing office papers (A4);
   - Determining the carbon footprints of Information and Communication Technology equipment (computers, laptops, printers, cell phones);
   - Determining the carbon footprint of air conditioners.
2. To determine the perception of climate change among managers and operational employees was achieved by:
   - Conducting face –face interviews with managers in the different facilities.
   - Conducting face-face interviews with operational employees in the different facilities.
3. To identify potential mitigation strategies to reduce emissions.

1.5 METHODOLOGY

In order to meet the objectives of the study, it was necessary to use two methodologies, namely a quantitative and a qualitative study design. These research designs focus on different aspects in the study and are not intended for correlation purposes. These methodologies are briefly described.

1.5.1 Quantitative study design

In quantitative research, numerical data are analysed in order to understand the phenomenon under investigation and includes counting, standard deviations and other complex procedures (Mark, 1996:210). In this study it was appropriate to use a quantitative study design to achieve the first objective of the study, which was to estimate the carbon dioxide equivalent emissions of Ekurhuleni Health District and Provincial Clinics employees. The objective was achieved by using the Greenhouse Gas Protocol (GHGP) and Department of Environmental Forestry and Rural Affairs (DEFRA) methodologies. These methodologies are used internationally and using these methodologies will allow other researchers to replicate this study.

1.5.1.1 Organisation and operational boundaries

In the quantification of carbon footprints it's vital to set borders; the GHGP methodology dictates that organisational and operational boundaries should be defined (GHGP, 2012d). This study used control approach as an organisation boundary. In terms of operational boundary, the study includes the following scopes: Scope 1 accounts for direct emissions, such as government fleet vehicles; Scope 2 accounts for indirect emissions from purchased electricity; and Scope 3 accounts for indirect emissions, such as office paper, information and communication technology (ICT) equipment and air conditioners.

1.5.1.2 Sampling and data collection

A list of all the clinics within the Ekurhuleni Metropolitan Municipality (EMM) was obtained and thereafter all the GDoH provincial clinics in the list were selected so that organisational boundaries could be set. The facilities included in the study are indicated in Table 3.2. Prior data collection ethics clearance was obtained from University of South Africa (reference number 2013/CAES/030) and Ekurhuleni Ethics Committee (project number: 2013-09-2013-01). In addition, permission for data collection was obtained from the Chief Director of the District Office. These documents are presented in Appendix A, B and C. Carbon data variables were collected from different units within the Ekurhuleni Health District Office (see Table 3.1).

1.5.1.3 Data analysis

The carbon footprint of vehicles (Scope 1) was calculated by multiplying the fuel consumed (petrol & diesel) and the kilometres travelled by specific emission factors as determined by the DEFRA methodology. The GHG Protocol Tool for Mobile Combustion (version 2.6) Microsoft Excel spreadsheet made available by GHGP was also used. Manufacturer CO_2e emission was determined by multiplying the vehicle kilometres travelled by the vehicle manufacturer specific emission factors (see Chapter 3, section 3.6.1 for more information).

Carbon footprint of electricity (Scope 2) was determined by multiplying the kilowatts of electricity used by the Eskom emission factors for sold and generated electricity for that specific year in question (for more information refer to Chapter 3, Section 3.6.2).

Scope 3 includes emissions for printing paper that was quantified by establishing the weight of office papers per ream rather than per box and was multiplied by emission factors reported by Sappie and Mondi. The carbon footprints of ICT equipment was determined by using the Life Cycle Stage Ration, profiling the characterisation methodology, which allows for the quantification of carbon emissions based on the use stage of the ICT equipment multiplied by Eskom emission factors for each specific year. Lastly, the carbon footprint of air conditioners was determined by completing an Microsoft Excel spreadsheet as screening method made available by the GHGP (for more information consult Chapter 3, section 3.6.3, 3.6.4 and 3.6.5).

1.5.2 Qualitative study design

Qualitative research was used to determine the knowledge and perception phenomenon of climate change among managers and operational employees in Ekurhuleni Health District and Provincial Clinics. This study design was selected because it allows the phenomenon under investigation to be examined in detail and seek an in depth understanding and meaning for theory development (Daly, 2003:193). There are different types of qualitative research approaches and content analysis is one of these research approaches. Content analysis was appropriate in this study, as it permits the text to be examined in terms of the words and terms used, which are normally quantified by counting the frequency of the number of words or terms used (Miller & Brewer, 2003:44). Content analysis also shows the meaning or idea in a document by looking at the frequency of times the item appears or is used in the context (Jupp, 2006:41).

1.5.2.1 Sampling and data collection

In this study purposive sampling was used to select the participant managers and operational employees to determine their knowledge and perception of climate change. Purposive sampling was appropriate for this study, because it enables the selection of research participants that are knowledgeable and familiar with the phenomenon under investigation (Patton, 2002).

Structured face-to-face interviews were used as a tool for data collection, with an interview guide or schedule consisting of open-ended questions (see Appendix D). An interview schedule is a document with a list of questions, which are read to the research participants during the interview (O'Leary & Miller, 2003:253). Moreover, Barbour (2008:115) explains that an interview schedule consists of open-ended questions to allow the respondent to express their views. Usually it would start off with the less complicated questions. All the research participants were asked to sign a consent form prior to the interview (see Appendix E).

In addition to the interview schedule, a tape recording device was used. The aim of using the tape recorder was to assist the researcher in capturing the various information and opinions regarding the perception of climate change and to review the information in more detail. Prior data collection ethics clearance was obtained from University of South Africa (reference number 2013/CAES/030) and Ekurhuleni Ethics Committee (project number: 2013-09-2013-01), which are provided in Appendix A and B respectively.

1.5.2.2 Data analysis

Verbal interview responses were transcribed by means of Microsoft Word. Verbal transcription is writing down the exact words uttered by the research participants (Smith & Davies, 2010:148). All interview responses were coded, for example: the responses of the managers were coded as A1 to A10 and the responses of the operational employees were coded as B1-B23.

The transcript was read several times on different days in order to identify the emerging knowledge and perceptions from the interview transcripts. Content analysis was used to organise information systematically so that emerging keywords could be identified and possible themes formulated (Brewer, 2003:45). The keyword descriptions were quantified in a frequency table to identify re-occurring keywords and descriptions, which were used to develop emerging themes as per content analysis methodology.

1.5.3 Study area

The study area of the research is the Ekurhuleni Metropolitan Municipality (EMM) in the Gauteng Province in the Republic of South Africa and covers an area of about 2 000 km^2 (Ekurhuleni Metropolitan Municipality, 2011:1). In the year 2000, local government restructuring was taking place. As a result, EMM was formed by combining two councils (Kyalami Metropolitan and East Gauteng Service Council) and nine other towns. The Municipality has a total population of approximately 2.8 million people, which makes up 5.6% of the total national population and 28% of the Gauteng Province population.

According to a document from the Directorate of Primary Health Care, the EMM is currently divided into six health sub-districts according to the equal distribution of health care facilities, management units and customer care areas (D. Chiloane, personal communication, 28 March 2012) (Figure 1.1). The primary health care sub-districts consist of local clinics which are controlled by the EMM and provincial clinics, which are owned and controlled by the Gauteng GDOH. The facilities in the different sub-districts within the EMM are provided in Chapter 3 (Section 3.4, Sampling criteria and Table 2).

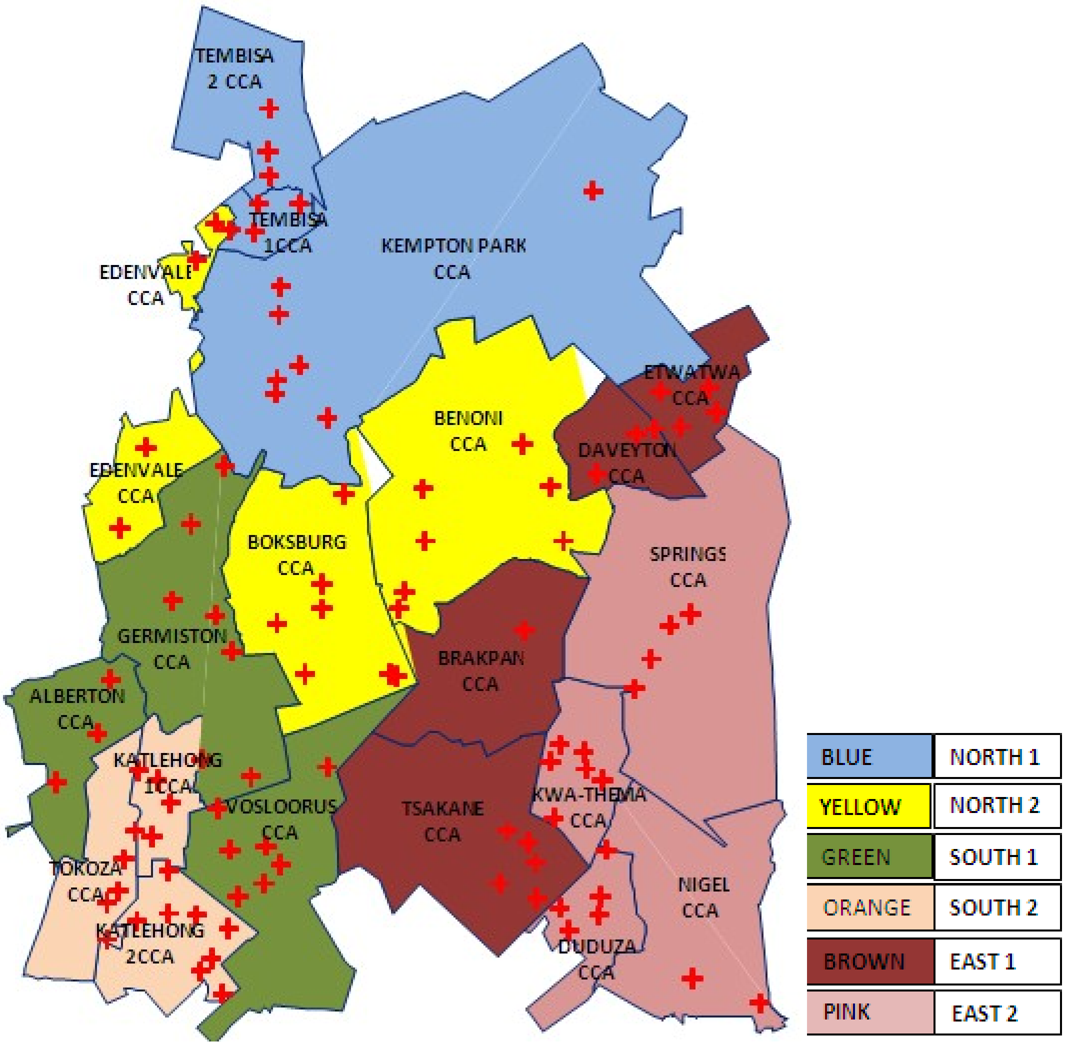


Figure 1.1 **Ekurhuleni Metropolitan Municipality (EMM) primary health care sub-districts** (D. Chiloane, personal communication, 28 March 2012)

1.6 LIMITATIONS AND ASSUMPTIONS OF THE STUDY

The limitations and assumptions in the study is presented per scope (1, 2 and 3) in accordance with the Greenhouse Gas Protocol structure. A more detailed discussion on the limitation and assumptions are presented in the respective sections of the dissertation.

1.6.1 Scope 1

Scope 1 (government vehicles) data limitation includes missing month's information, such as February 2010, March 2010, June 2010, July 2011 and August 2012. An average t CO_2e emissions was used, derived from the available fuel emissions (t CO_2e) for the period of 5 years. Some vehicles had missing fuel information and make/model (see section 3.6.1) in which average t CO_2e emission and petrol default emission factor was used respectively. It is assumed that these averages would be representative of the data. Officials with car allowance utilising their own private vehicles in rendering health services were excluded from the study.

1.6.2 Scope 2

In Scope 2 (electricity carbon footprint), the data limitation was that the average kilowatts was derived from two provincial clinics and used to calculate the carbon footprints of the ten facilities. It is assumed that the estimated average would be representative, because the two provincial clinics covers both larger and smaller facilitates.

1.6.3 Scope 3

In the office paper carbon footprint emissions, sixteen months of printing paper (office A4) data was missing (2010 and four months of 2011). Therefore, it was necessary to extrapolate the missing information by using the average number of office paper derived from the available information (April 2011 – December 2014), which was used to estimate the carbon footprint. This is considered as a limitation of the office paper carbon footprints results. However, it is assumed that the results could be considered representative.

The study limitation for the carbon footprint emissions from Information Communication Technology (ICT) equipment were: (1) In the use stage GHG emission assessment leave taken by employees was not taken into consideration; (2) The lowest power factor (watts) available was used in cases where the actual watts for the equipment were not obtainable from the manufacturer; (3) Standby carbon emissions were quantified for printers only; and (4) Possibility of double accounting for ICT CO_2e emissions, since ICT equipment uses electricity. The study limitation regarding air conditioners refers to the fact that an average number of air conditioners was obtained by using only the available information due to the unavailability of data at eight (8) facilities. It is assumed that the average used is acceptable representation, because it consists of different sizes of facilities. The methodology required certain information that could not be obtained (recharge years, number of equipment sent for destruction) and in this case zero was used as default value. Where the methodology required a default emission factor, the lowest available factor was used, which might underestimate some of the results.

1.7 SEQUENCE OF CHAPTERS

Chapter 2 that follows this chapter is devoted to a *Literature Review* to provide a contextual framework and background to the research problem. To operationalise the research problem, the *Methodology* is described to address the objectives of the research in Chapter 3. The results of the study are presented in two chapters. Chapter 4 focuses on the results regarding the *Carbon Footprints*, while Chapter 5 covers the *Knowledge and Perceptions of Climate Change*. Finally, the *Recommendations and Conclusions* are offered in Chapter 6.

Chapter 2
LITERATURE REVIEW

2.1 CLIMATE CHANGE AND GLOBAL WARMING

2.1.1 Description of climate change and global warming

The terms "global warming" and "climate change" can be used interchangeably, however, the term "climate change" is preferable (Maltzman & Shirley, 2011:3-4). Climate change is defined as a continuous measure of the change over a period of time (Cuevas, 2011:32; Polivka, Chaudry & MacCrawford, 2012:321). Moreover, Lyons (2015:36) defined climate change as the alteration of the earth's climate resulting in the warming of oceans, rising sea levels, melting of ice caps and changing in natural phenomenon. Scholes, Scholes & Lucas (2015:1) concur that, global warming is the result of an increase in average temperature where the increase in temperature causes disturbances in the climate system.

The majority of scientist worldwide concur that, climate change is caused by human activities that produce Greenhouse Gases (GHG) (Filiberto, Wethington, Pillemer, Wells, Wysocki & Parise, 2009:19; Mertz, Halsnaes, Olesen & Rasmussen, 2009:743; Tseng, Chen, Chang & Chu, 2009:124; Kumaresan *et al.*, 2011:201; Perlmutter & Rothstein, 2011:66). The link between human activities and the warming of the planet dates back to century ago (Toulmin, 2009:15-16). Table 2.1 presents a brief history of climate change timeline, as explained by Stoffberg & Prinsloo (2009) in their book titled "*Climate change a guide for corporates*", the authors provide historical milestone events in climate change i.e. the establishment of greenhouse gas effects, the association between climate change and melting of glaciers etc.

GHG are those gases found in the atmosphere which can be natural or human induced, the primary gases found in the atmosphere are: water (H_2O) vapour, Carbon dioxide (CO_2), Nitrous oxide (N_2O), Methane (CH_4) and Ozone (O_3) (IPCC, 2013b:1455). In addition to CO_2, CH_4 and N_2O, there are also other human induced greenhouse gases in the atmosphere, such as Sulphur hexafluoride (SF6), Hydrofluorocarbon (HFC), Perfluorocarbon (PFC), and more (IPCC, 2013b:1455).

Table 2.1 **Brief history of climate change timeline** (Stoffberg & Prinsloo, 2009)

Timeline	**Climate change milestone**
1800	Global temperature shift begun, earth changed from snowball to warmer temperature.
1827	Joseph Fourier established the concept of greenhouse gas effect
1860s	John Tyndall discovered that climate change can occur due to the effects of greenhouse gases emissions resulting in glacier melting.
1896	Savante Arrenius demonstrated the linkage between global warming and atmospheric CO_2
1800 –1870	First industrial revolution: coal usage and clearing land for human activities result in greenhouse gas level increase.
1870 –1910	Second Industrial revolution: greenhouse gas further accelerates due to introduction of chemicals, fertilisers and electricity.
1988 – 1989	Intergovernmental Panel on Climate change (IPCC) is established and the Montreal Protocol is drafted.
1990 – 1995	First and second IPCC reports published and Kyoto Protocol commitment by various countries
2001 - 2017	Third and fourth IPPC report published, increase temperature results in number of death in Europe due to heatwave (2003), among other developments the Paris agreement is ratified by various countries.

Scientific data from the ice cores have shown an increase of Carbon dioxide (CO_2), Methane (CH_4) and Nitrous oxide (N_2O) at a rate of 40%, 150% and 20% respectively from the year 1750 to the year 2011, as shown on the Figure 2.1 (IPCC, 2014:44). The green dotted line represents CO_2, the orange CH_4 and the red N_2O.

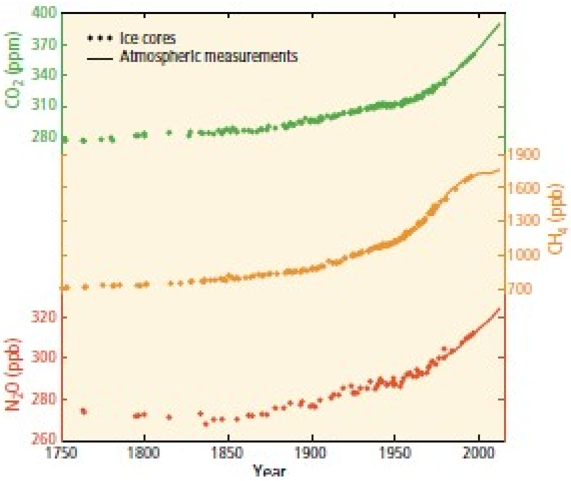


Figure 2.1 **Global averaged greenhouse gas concentration observed from 1750 to 2010** (IPCC, 2014:44)

Carbon dioxide (CO_2) makes up 63% of the warming effects in the long term, in comparison to other GHGs, therefore, CO_2 equivalent (CO_2e) is used to quantify global warming potentials of GHG (May & Caron, 2009:27).

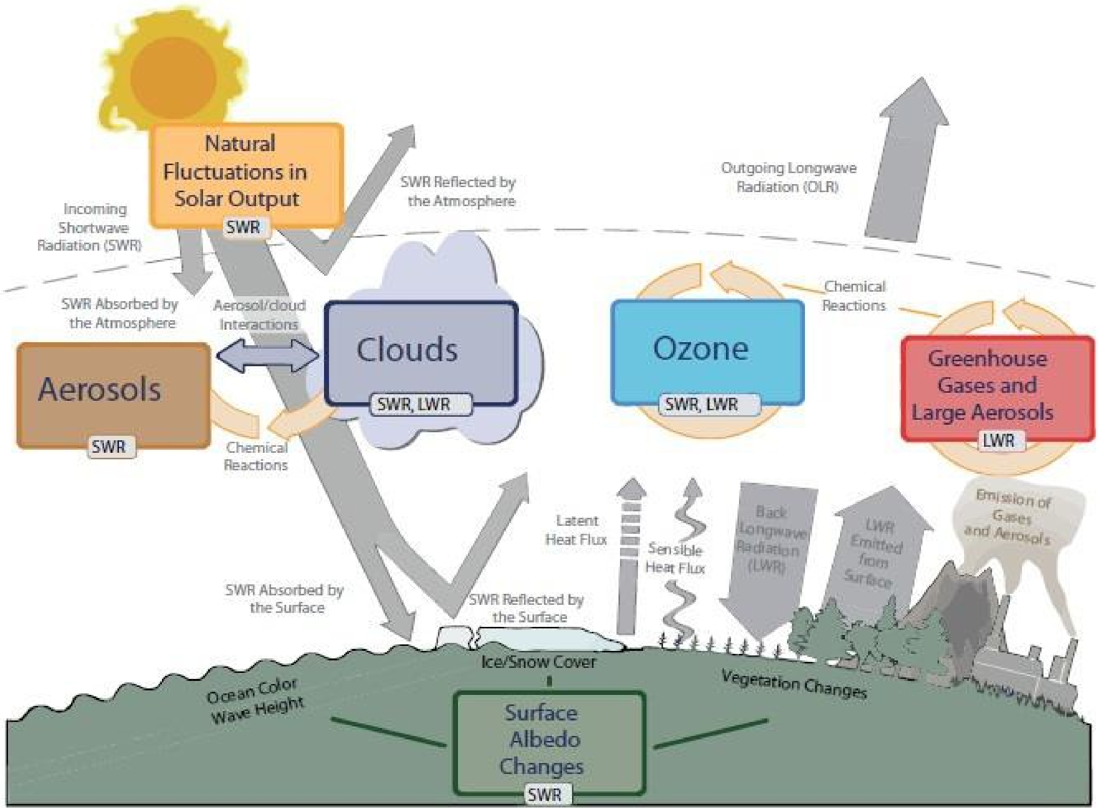


Figure 2.2 **Main drivers of climate change and greenhouse effect** (Cubasch *et al.*, 2013:126)

Figure 2.2 presents the main drivers of climate change and greenhouse effect. The sun as a source of energy that emits incoming solar Shortwave Radiation (SWR) to the planet, where 50% of the SWR is absorbed by the earth surface and a portion is reflected back into space. Depending on the earth's temperature, the majority of the Longwave Radiation (LWR) emitted by the earth surface is absorbed by GHGs. These GHGs also emit LWR in all directions, the downward portion of LWR increases the heat on the lower layer of the atmosphere causing the greenhouse effect (Cubasch *et al.*, 2013:126).

According to the 2014 IPCC report (IPCC, 2014:4-5), human induced climate change is extremely likely, the GHG emissions have increased since pre-industrialised time and it has reached the highest level ever. Figure 2.3 shows the total annual anthropogenic GHG emissions by gases from 1970 to 2010. It can be seen that the GHG emissions increased annually by 1.3% from 1970 to 2000 and 2.2% annually from 2000 to 2010, reaching its highest level ever in 2010.

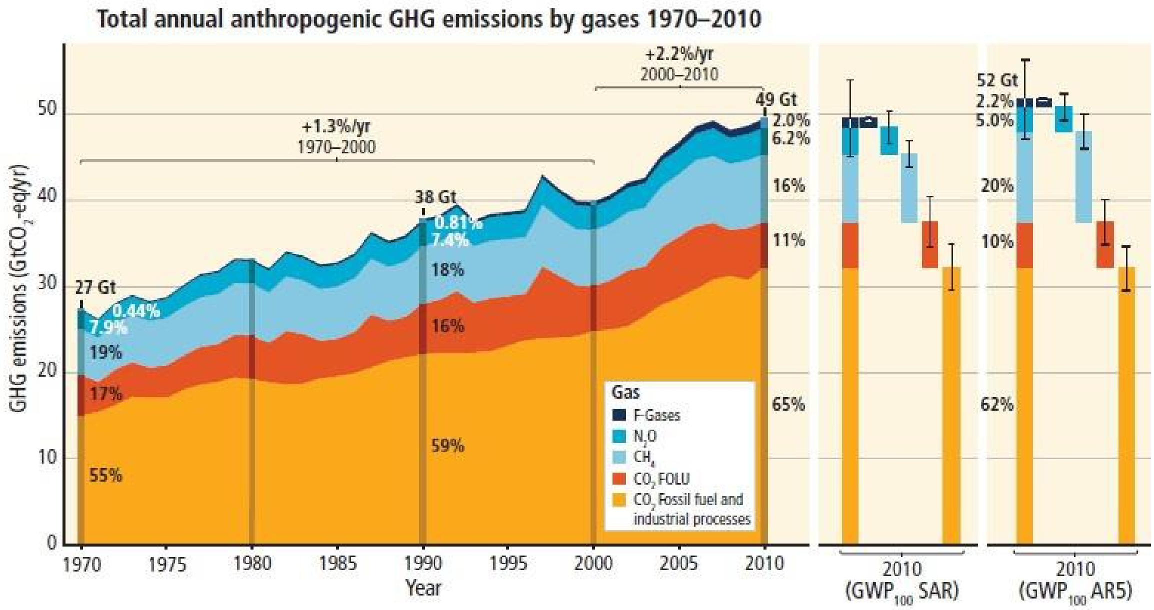


Figure 2.3 **Total annual anthropogenic GHG emissions by gases from 1970 to 2010** (IPPC, 2014:26)

In contrast to the human induced climate change theory, there is a body of scientists who reject the human induced climate change theory. For example, Spence (2012:1-6) explains that climate change is a natural process where the earth experiences warming and cooling phases, based on the medieval warm period around 1000 A.D. followed by little ice age several hundred years later. In addition, Philander (2008:3) believes that climate change is not caused by the increase of Carbon dioxide.

However, the majority of the scientific community agreed that the proof of climate change cannot be ignored (Cuevas, 2011:31). Weart (2011:41) elaborated that it took a variety of evidence to convince experts on the theory of climate change and human activities. In addition, the expert organisation on climate change, IPCC, has indicated that climate change is very likely to be associated with human activities (Denman, Brasseurs, Chidthaisong, Ciais, Cox, Dickinson, Hauglustaine, Heinze, Holland, Jacob, Lohmann, Ramachandran, Dias, Wofsy & Zhang, 2007:511).

2.1.2 Global perspective

The majority of the scientists worldwide have concluded that climate change is the biggest threat facing the world today (Goklany, 2009:69; Bell, 2011:804; Kumaresan *et al*., 2011:201; Regan *et al*., 2012:1). Temperature and precipitation are the most important information factors regarding climate change (Chenkova & Nikolova, 2015:S381).

According to the IPCC (2013a:5- 6), the planet has exprienced an increase in the global temperature from 1901 to 2012 calculated from linear regression temperature trends from a dataset, as indicated in Figure 2.4. Similarly, the earth's surface has experienced the warmest temperatures in the past 30 years in comparison to 1850, the combined average temperature from the ocean and land surface is presented in Figure 2.5, which shows a warming of 0.85°C from 1880 to 2012.

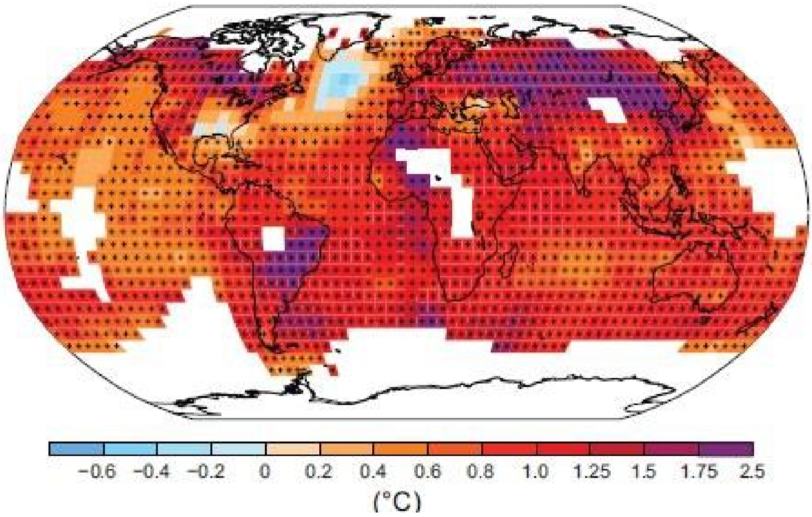


Figure 2.4 **Observed changes in surface temperature from 1910 to 2012** (IPCC, 2013a:5-6)

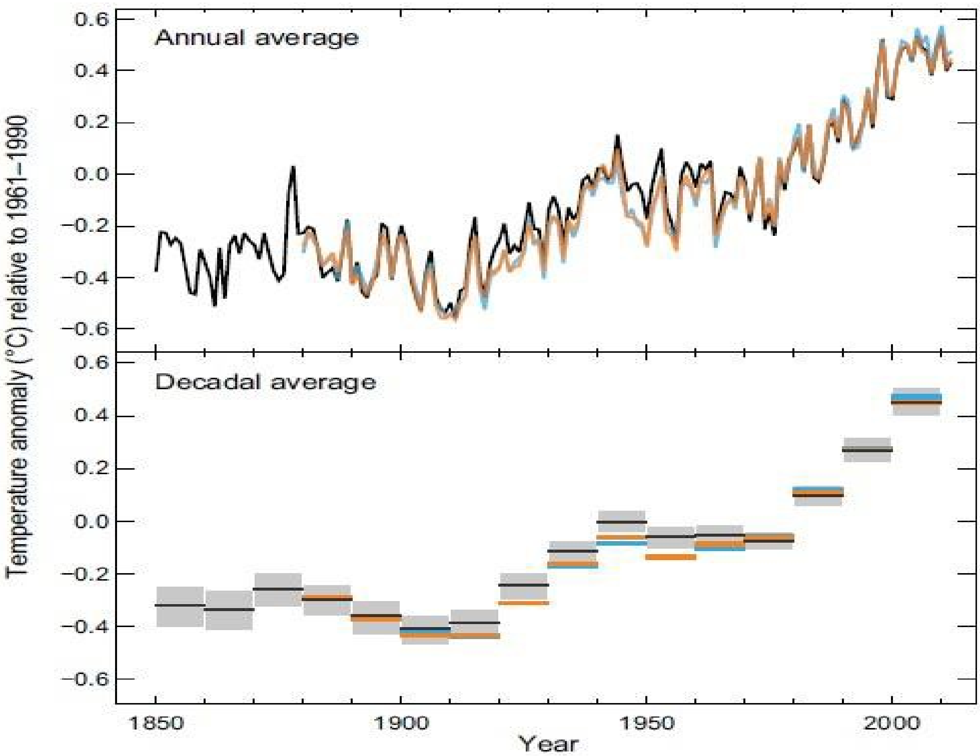


Figure 2.5 **Average global anomaly temperature from oceans and land surface from 1180 to 2012** (IPCC, 2013a:5-6)

Worldwide, the majority of countries are experiencing increased temperature based on temperature projection studies on meteorological stations. For instance, temperature data from meteorological stations in Bulgaria between 1984 and 2010 showed a positive trend of 0.7ºC–0.8ºC temperature increase per ten years in the summer. The projected temperature increase of 1.4ºC–2.2ºC is anticipated between 2021 and 2050 and a maximum of 2ºC–3.7ºC between 2051 and 2080 (Chenkova & Nikolova, 2015:S388).

Furthermore, a study conducted by Silva and Sonnadara (2016:70) concur with the increase in temperature. Information from a weather station in Sri Lanka was analysed for the period 1869–2006 and displayed a temperature increase of 0.2ºC–0.8ºC with the highest recorded temperature of 1.1ºC in one of the weather station. Similarly, temperature trends in China between 1962 and 2011 display a temperature increase of 0.9ºC, showing an increase of 0.2ºC per decade (Lin, Zhu, Wang, Gong & Zou, 2016:8). Many other geographically important studies on temperature projections were conducted in different areas, showing an increase in temperature, such as the Mediterranean regions (Giorgi & Lionello, 2008:90-104), Central America (Hidalgo *et al*., 2013:94-112), Southern and Western Africa (New, Hewitson, Stephenson, Tsiga, Kruger, Manhique, Gomez, Coelho, Masisi, Kululanga & Mbambalala, 2006:1-11) and Tianshan Mountains in Central Asia (Deng, Chen, Wang & Zhang, 2015: 28-37).

Precipitation is also an important feature in climate change. Current studies on precipitation projections show an overall decrease or increase of precipitation, for instance a study conducted by Giorgi and Lionello (2008:102) present a projected decrease of about 25-30% in precipitation in the Mediterranean regions for the period of 2070-2099. In contrast, an investigation of the future extreme precipitation projections over Europe for the period 2070–2100 showed a decrease in mean precipitation in some regions. However, a 50% increase in precipitation over most regions in Europe was noted, based on the atmospheric regional climate model REMO (Semmler & Jacob, 2004:126).

In South Korea, a study was conducted to examine the seasonal drought at weather stations from 1985–2000, which shows that with 30% of the droughts occurring in winter months, it is projected that in 2015-2040 there will be 13 years of consecutively dry seasons in one of the stations (Waseem, Park & Kim, 2016:286). Numerous geographical important studies have been documented that display an increase or decrease in precipitation projections, for example Central America (Hidalgo *et al*., 2013:94-112), Mumbai India (Rana, Foster, Bosshard, Olsson & Bengtsson, 2014:107-128), Mediterranean basin in southern Italy

(Senatore, Mendicino, Smiatek & Kunstmann, 2011:70-92), European countries (Madsen, Lawrence, Lang, Martinkova & Kjeldsen, 2014:3634-3650), Tianshan Mountains in Central Asia (Deng *et al*., 2015: 28-38)

2.1.3 Africa and Southern Africa perspective

Africa is considered the most vulnerable continent to climate change because of poor adaptive capabilities (Stringer *et al*. 2009:1; Dennis & Dennis, 2012:417). The surface temperature in the continent has increased by 0.5°C or more in the past 50 to 100 years. It is projected that the mean annual temperature will continue to increase throughout the continent in the mid-21st Century by over 2°C and over 4°C in the late-21st Century under the Representative Control Pathway (RCP) 8.5, as illustrated in Figure 2.6 (Niang, Ruppel, Abdrabo, Essel, Lennard, Padgham & Urquhart, 2014:1206-1207).

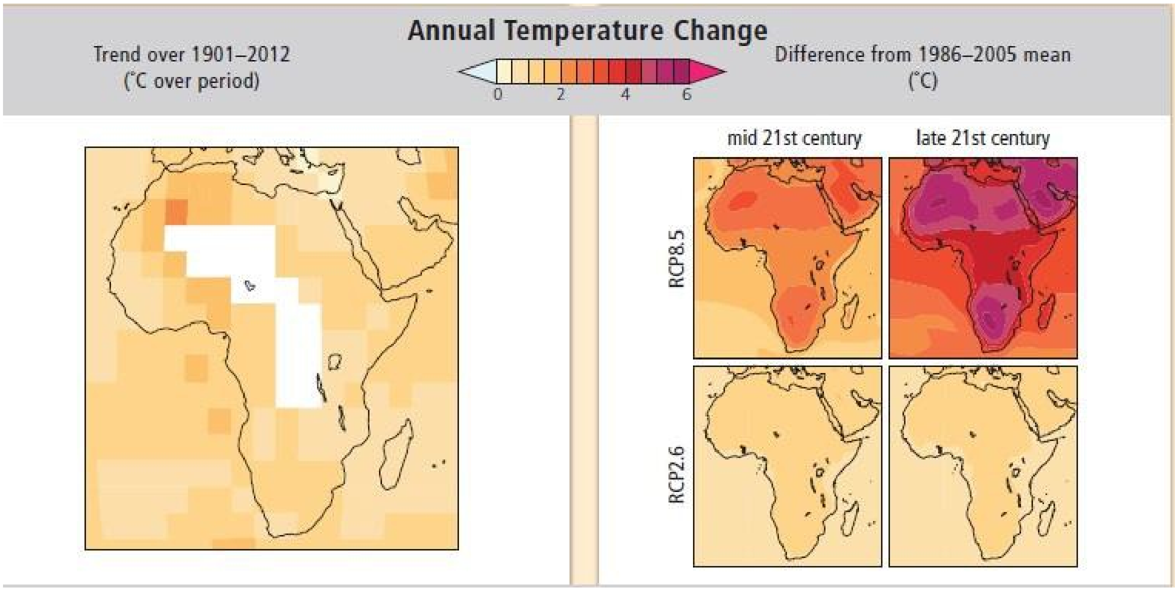


Figure 2.6 **Observed and projected annual temperature changes over the African continent** (Niang *et al*., 2014:1206-1207)

According to a study conducted by Engelbrecht, Adegoke, Bopape, Naidoo, Garland, Thatcher, McGregor, Katzfey, Werner, Khoku & Gatebe (2015:2-3) in which 50 years temperature data from 1961 to 2012 were analysed based on a temperature land station data set provided by the Climate Research Unit (CRU). They reported that temperatures in Africa have been increasing quickly over the past 50 years. In fact, the temperature trends in some regions in the continent (subtropical Southern Africa, Northern Africa and Central Africa) had increased twice compared to the (3.2°C/century) global land-based temperature (1.12°C/century). Figure 2.7 presents the average annual near-surface temperature (°C/century) between 1961 - 2012. It can be noted that the highest temperature increase occurred in Southern Africa, Northern Africa and parts of central Africa (Engelbrecht *et al.*, 2015:2-3).

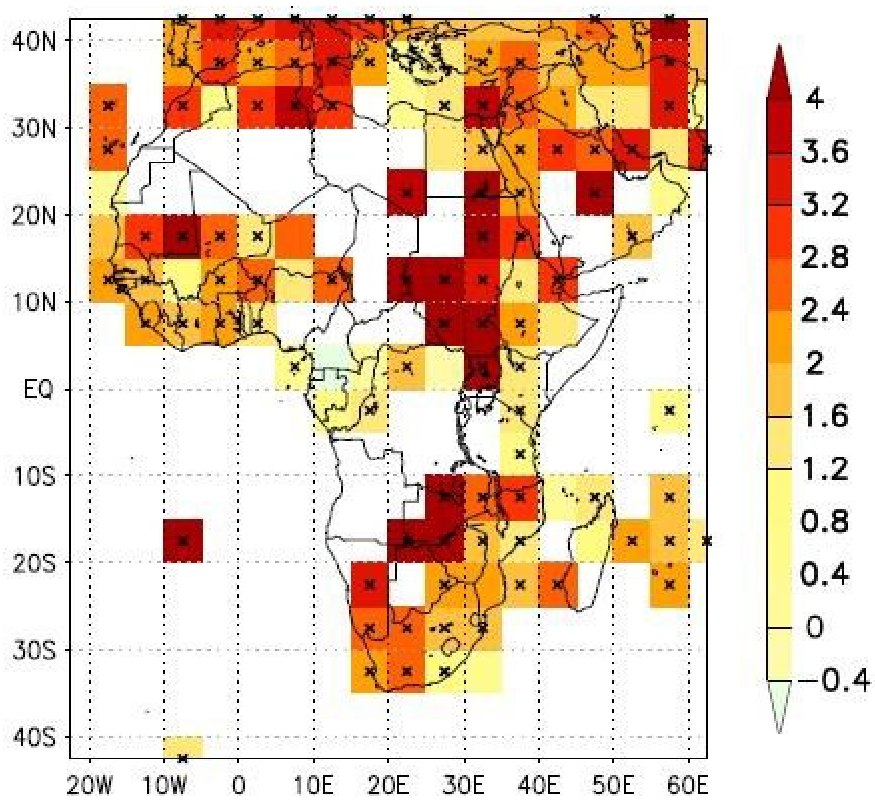


Figure 2.7 **Averaged annual near-surface temperature (ºC/century) for 1961-2012 in Africa** (Engelbrecht *et al.*, 2015:2-3)

Northern Africa is considered a water scarcity region. Currently there are more than 240 million people at risk of water stress. Countries like Libya and Egypt use almost 90% of the water made available to them each year, while Sudan, Morocco, Algeria and Tunisia use 50%. Therefore, with the projection of a decrease in rainfalls and an increase evaporation rate due to climate change, it will place further strain on the water resources (Toulmin, 2009:40). In addition, precipitation is predicted to decrease in Northern Africa regions (Toulmin, 2009:30). Morocco is a country situated in North Africa that is vulnerable to extreme precipitation. A study conducted by Tramblay, Badi, Driouech, El Adlouni, Neppel & Servat (2012:104) shows an average of 12% decrease in precipitation based on Regional Climate Model (RCM) projections for the period 2070-2099. Schilling *et al.* (2012:24) point out that countries in North Africa, such as Algeria, Egypt, Libya, Morocco and Tunisia, will experience 10-20% decreases in precipitation under the SRES A1B model until 2050.

In the West African region, a study conducted by Aich, Liersch, Vetter, Fournet, Andersson, Calmanti, Van Weert, Hattermann & Paton (2016:666-667) on the Niger River Basin, demonstrated an increased flood risk on the upper, middle and lower Niger River based on 2021-2051 projections. Research projection further indicated that the temperature in Africa will continue to increase (Toulmin, 2009:30). Adakayi and Ishaya (2016:226) projected that between 2007 and 2030, the temperature in Nigeria is expected to increase by 0.4^{o}C. Mijinyawa and Osiade (2011:561) highlighted that Nigeria is experiencing a decline in agriculture production, which is threatening food security in the country due to climate change. In Cameroon, the agriculture sector concluded that increasing temperature and decreasing rainfall caused much damage to agriculture crops (Ngondjeb, 2013:93).

Southern Africa is experiencing severe drought (Unganai & Kogan, 1998:219). The United Nation (UN) World Food Program declared seven countries in the Southern Africa region, namely Zimbabwe, Zambia, Swaziland, Mozambique, Malawi, Madagascar and Lesotho, as high-level emergency countries due to drought affecting crops and placing 18 million citizens from these countries in need of urgent food assistance (*News 24*, 2016). Zimbabwe is experiencing the effects of climate change in terms of increased average temperatures and a decrease in rainfall patterns. Sango and Godwell (2015:4-5) analysed temperature and rainfall meteorological data from 1961 to 2011 in the Makonde Rural District. The results show that temperature is increasing while rainfall is decreasing. As a result, Zimbabwe experienced drought in 2010 (Scholes *et al.*, 2015:29). A projection study, by Mujere and Mazvimavi (2012:545), examining temperature and hydrological data, highlighted that in 2050 the mean monthly temperature in Zimbabwe will increase by 3^{o}C and rainfall will increase by 15%, based on double the carbon dioxide emissions by 2050. In addition, the temperature is increasing and the droughts are occurring more frequently in Malawi (Joshua, Ngongondo, Mwathunga, Liwenga, Stathers, Chipungu, LambolL, Majule & Ndau, 2015:134).

Figure 2.8 displays temperature projections for Southern Africa based on Global Climate Models (GCM) for the period 2030-2060, in which two scenarios are presented, namely B1 where humanity will reduce the use of fossil fuel and implement cleaner technology, and scenario A2 where humanity will continue using fossil fuel and the population will continue to increase. The projections from both scenarios indicate temperature increases of 1–3^{o}C for the year 2060. It should be noted that in scenario A2 temperatures are much higher in the southwest of the continent (Davis 2011:35).

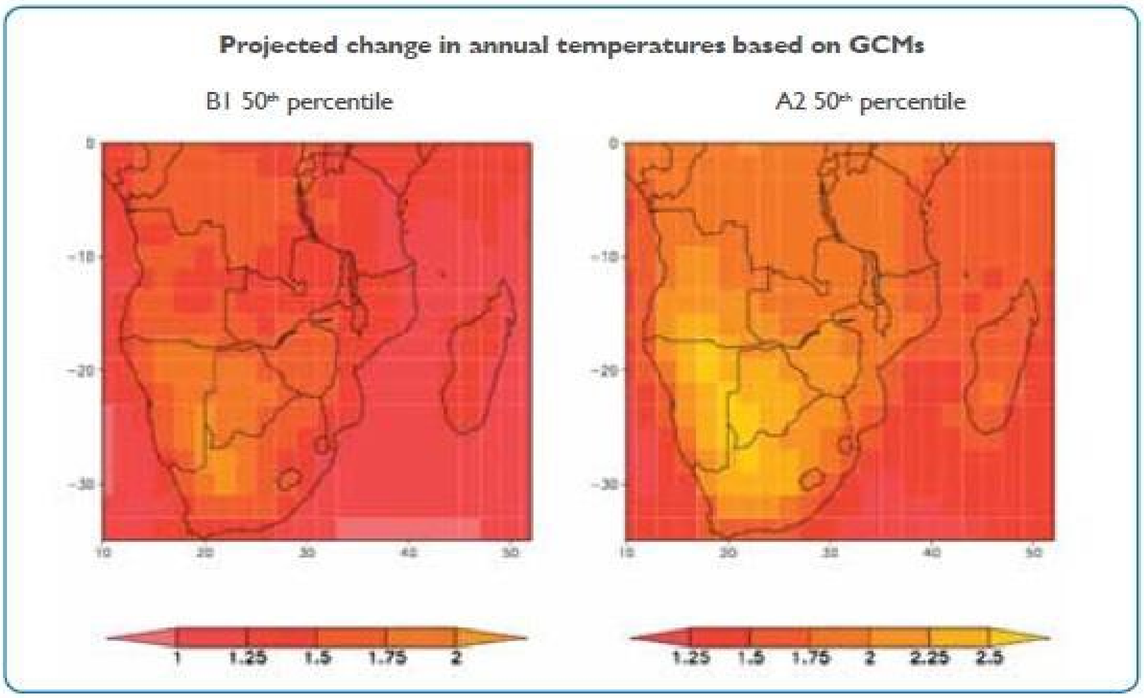


Figure 2.8 **Changes in the mean annual average temperature by 2030-2060 for scenario B1 and A2** (Davis, 2011:35)

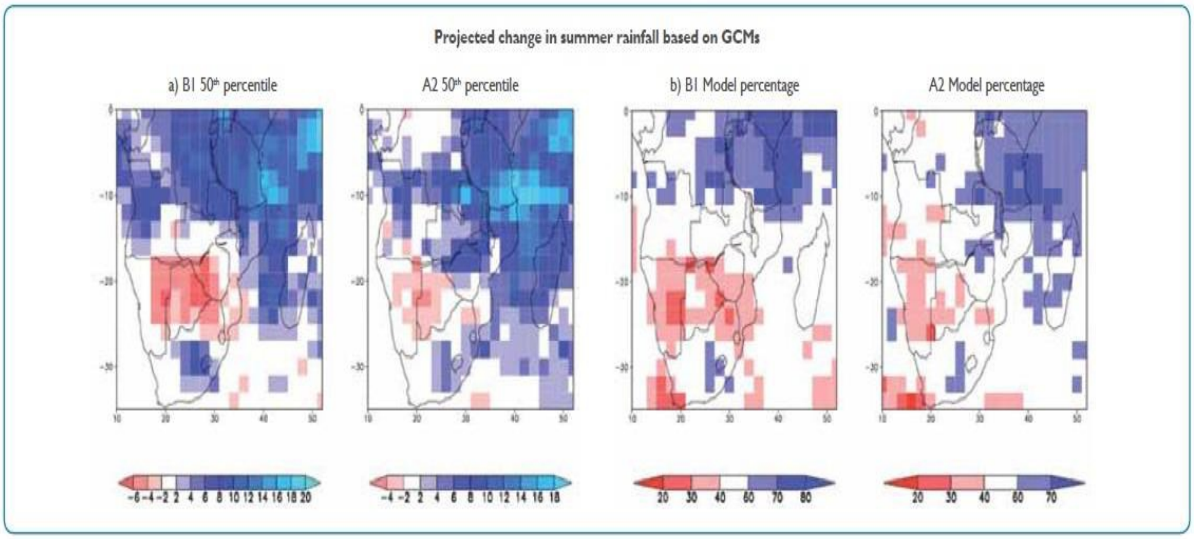


Figure 2.9 **Summer season mean change in average rainfall (mm) by 2030-2060 and model percentage showing increase in rainfall** (Davis, 2011:33)

In terms of precipitation projections in Southern Africa, Figure 2.9 illustrates the seasonal projection for the period 2030-2060 for scenario B1 and A2. The rainfall in summer (December, January and February) shows less rainfall over the central southern Africa region and an increase in rainfall in the northern and eastern part of the continent and similar projections are also evident in other seasons (Davis, 2011:33).

2.1.4 South African context

South Africa is considered a water-scarce country (Tshiala, Olwoch & Engelbrecht, 2011:14) with average annual precipitation of 500mm while the global annual average rainfall is 860mm (Dennis & Dennis, 2012:417). In June 2016, eight of the nine provinces in South Africa were declared in a state of disaster by the Minister of Governance and Traditional Affairs, Mr. Des van Rooyen. This declaration of a state of disaster was due to drought as a result of low rainfall, increased maximum temperatures and heatwaves (*News 24*, 2016)

Temperature increase results in the increase of evaporation and precipitation causing droughts and floods (Tshiala *et al*., 2011:14). Temperature data from 970 weather stations in Limpopo Province, South Africa was studied by Tshiala *et al.* (2011:16) who reported that the highest mean average annual temperature was 0.1°C/decade in one catchment area and the lowest was -0.03°C, displaying warming temperature in some areas.

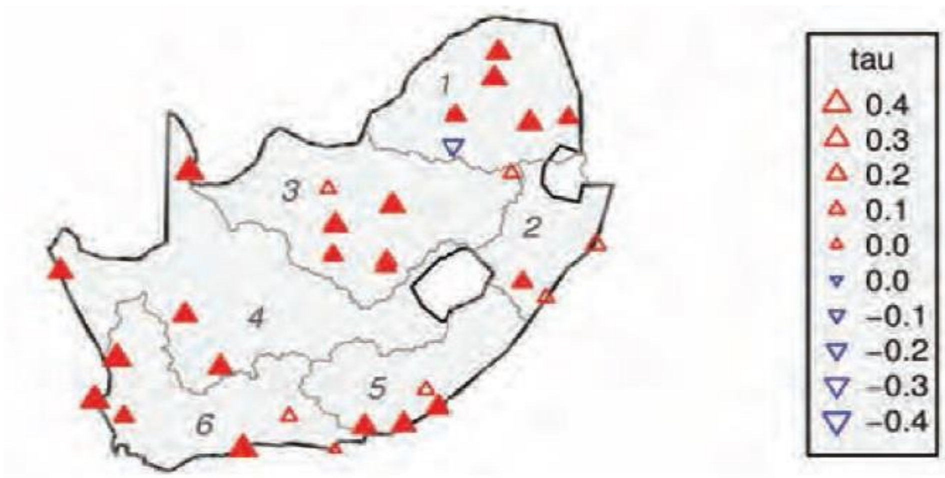


Figure 2.10 **Trends in annual mean maximum temperatures from 1920 to 2010 in South Africa** (Mackellar *et al*., 2014:6)

Temperature data for a period of 20 years (1960–2010) from weather stations across South Africa was studied by Mackellar *et al.* (2014:1-13). They concluded that the maximum temperature has increased significantly throughout the county, as shown in Figure 2.10. The filled triangle indicates a significant increase in temperature and the numbers 1-6 represent the different regions throughout the country: (1) Limpopo and part of Northern Mpumalanga; (2) KwaZulu-Natal and part of Southern Mpumalanga; (3) Northern and Central interior; (4) Northern Cape, Southern Free State and part of Eastern Cape; (5) Eastern Cape and part of KwaZulu-Natal; and (6) Western Cape and part of Northern and Eastern Cape (Mackellar *et al.* 2014:6).

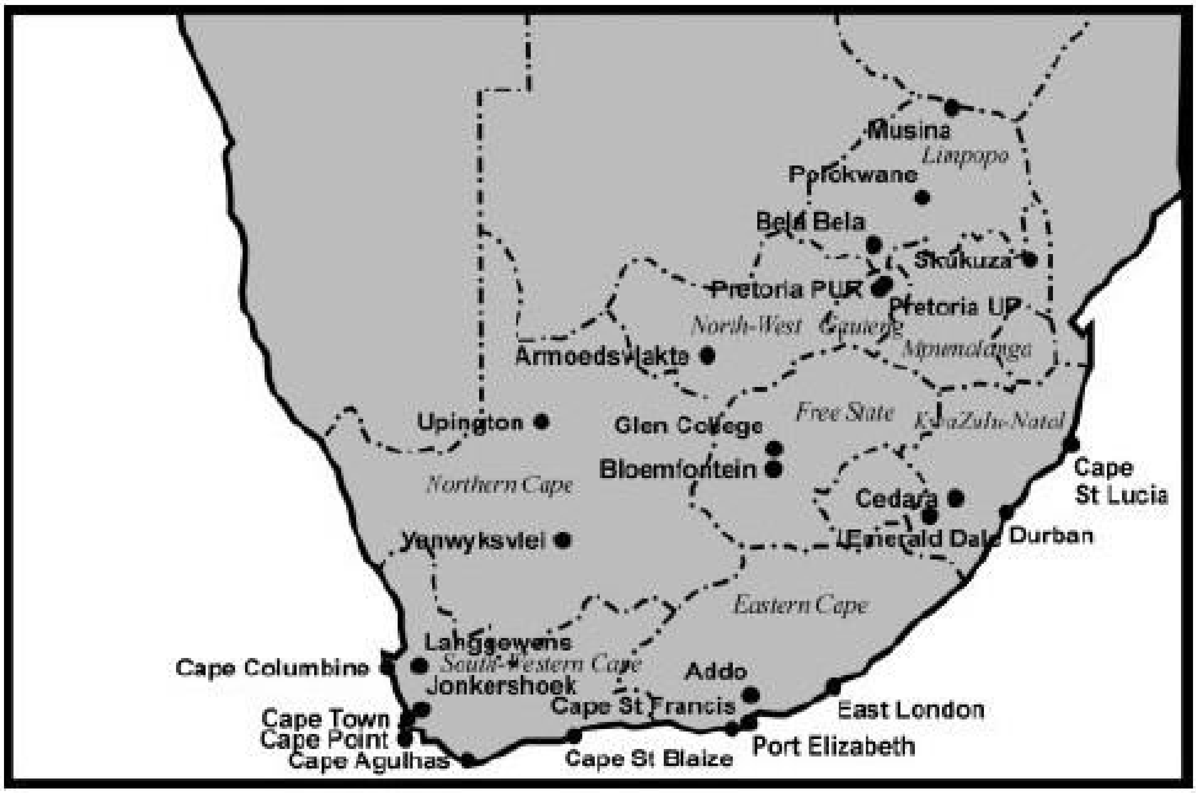


Figure 2.11 **Location of the weather stations analysed for annual mean maximum temperature** (Kruger & Shongwe, 2004:1931)

A similar study was conducted by Kruger and Shongwe (2004:1929-1945), where temperature data from twenty three (23) stations throughout the country, obtained from the South Africa Weather Service Climate database (SAWSCD), was analysed. Figure 2.11 presents the location of these stations where the names of the stations are in bold and the provinces are in italics (Kruger & Shongwe, 2004:1930-1931). The results indicated an increased average maximum temperature at 88% of the stations of which 50% were significant. The highest recorded temperature was 0.4ºC/decade in the Northern Cape, while the lowest was -0.3ºC/decade in Pretoria. As shown in Figure 2.12, the ***** symbol in the station name denotes a significant increase in temperature (Kruger & Shongwe, 2004:1930-1932).

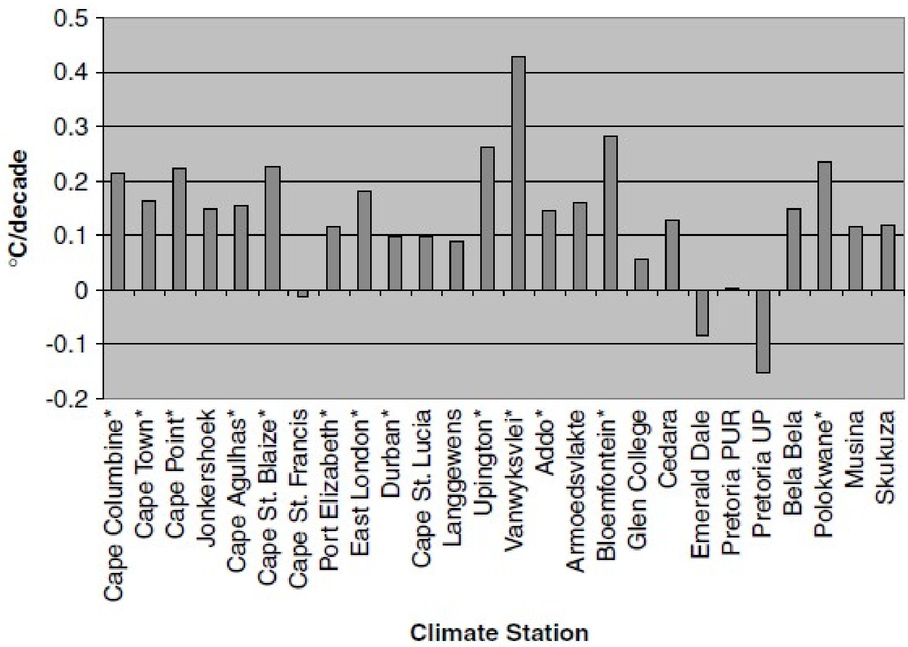


Figure 2.12 **Annual mean maximum temperature trends (ºC/decade) for the period 1960 to 2003 in South Africa** (Kruger & Shongwe, 2004:1931)

2.2 CARBON FOOTPRINT

The definition of carbon footprint originates from the concept of ecological footprint, which means the amount required to fulfil the population resource demand (Ramsay & Naidoo, 2012:174). Carbon footprint can be defined as the total amount of CO_2 emissions produced either directly or indirectly by activities, products or processes (Wang *et al*., 2015:464; Liu *et al.*, 2016:674-680;).

Carbon footprint evaluates the emissions of GHGs produced by a person, organisation, process or activities (Rossi *et al*., 2016:97). GHGs includes carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbon (HFC), perfluorocarbon (PFC) and sulphur hexafluoride (SF_6), as indicated in the Kyoto Protocol (Rossi *et al*. 2016:97). From the six mentioned GHGs, there are three (3) GHGs which are considered important in the causative of human inducted climate change, namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Kucukvar, Egilmez, Onat & Samadi, 2015:47).

Various studies have been conducted on an international level based on carbon footprint, for example carbon footprint of a lightning system (Rossi *et al*., 2016:96-103), carbon footprint of beef cattle (Cerri & Cerri, 2016:2593-2600), wind farm (Ji & Chen, 2016:416-4230), Lithium battery industries (Wang, Chen, Yu, Wang & Zhang, 2016:1-11), pallet manufacturer (Tornese, Carrano, Thorn, Pazour & Roy, 2016: 630-642), public procurement in a food industry (Cerutti *et al*., 2016:82-93), scientific publication at Dalian University of Technology (Song, Che & Zhang, 2016-275-282), cheese produced from milk (Kristensen, Søegaard & Eriksen, 2015:229-237), university students (Utaraskul, 2015:1156-1160), extra virgin olive oil (Pattara, Salomone & Cichelli, 2016:533-547), carbon footprint of honey (Mujica, Blanco & Santalla, 2016: 50-60), Laptops (Liu *et al*., 2016:674-680), carbon footprint of milk (Batalla *et al.*, 2015:121- 129), movie distribution via the internet (Hochschorner, Dán & Moberg, 2015:179-207), sawn timber products (Martinez-Alonso & Berdasco, 2015:127-135), sugar production (Garcia *et al*., 2016:2632-2641) and textile industry (Wang *et al.*, 2015:464-475; Yan *et al*., 2016:119-125).

Methodologies used for the quantification of carbon footprints included DEFRA (Ramsay & Naidoo, 2012:174-190), Life Cycle Assessment tool (Batalla *et al*., 2015:121-129; Hochschorner *et al*., 2015:179-207; Kristensen *et al*., 2015:229-237; Cerutti *et al*., 2016:82-93; Garcia *et al*., 2016:2632-2641; Ji & Chen, 2016:416-423; Liu *et al*., 2016:674-680; Mujica *et al*., 2016:50-60; Pattara *et al.*, 2016:533-547; Rossi *et al.*, 2016:96-103; Song *et al.*, 2016:275-282; Wang *et al*., 2016:1-11; Yan *et al.*, 2016:119-125), Multi Regional Input-Output (MRIO) analysis (Asane-Otoo, 2015:426-435), web-based calculators (Utaraskul, 2015:1156-1160), PAS 250 (Martinez-Alonso & Berdasco, 2015:127-135) and top-down and bottom-up approach (Wang *et al.*, 2015:464-475).

Carbon footprint quantification studies in Africa are not well documented in comparison to international studies. A literature review on carbon footprints in Africa revealed few studies, for example: Asane-Otoo (2015:426-435) investigated the carbon footprint associated with African countries in terms of trading focusing on net-exporter and net-importer countries. The study identified Egypt, Tunisia, Nigeria, Zimbabwe, South Africa and the rest of North Africa countries as net exporters of embodied emissions, while the rest of the African countries were net-importers. In South African context, a study conducted by Ramsay and Naidoo (2012:174-190) investigated the carbon footprint of a community located in the vicinity of Tara Road in Durban, where carbon emissions of vehicles, households and commercial properties were quantified.

2.3 EFFECTS OF CLIMATE CHANGE

2.3.1 Agriculture and food security

Agriculture is expected to be severely impacted, which will have an impact in food security (Thornton, Jones, Ericksen & Challinor, 2011:117). Climate change will have an impact on the whole spectrum of food security from production, access to food and food utilisation (Singh, Vara, Prasad & Reddy, 2015:119). The increase of temperature affects plant growth, since plants require certain temperature and water content to grow (Tshiala *et al.*, 2011:14). Climate change will have an impact on water availability affecting agriculture (Sperna Weiland, Van Beek, Kwadijk & Bierkens, 2012: 1037).

The IPCC (IPCC, 2014:13) predicts food insecurity, especially for wheat, rice and maize, if the global temperature increases by 4°C and more by the 21 Century without adaptation measures, production levels will be affected. Changes in yield production for wheat, rice and maize are illustrated in Figure 2.13, which shows an overall decrease in production.

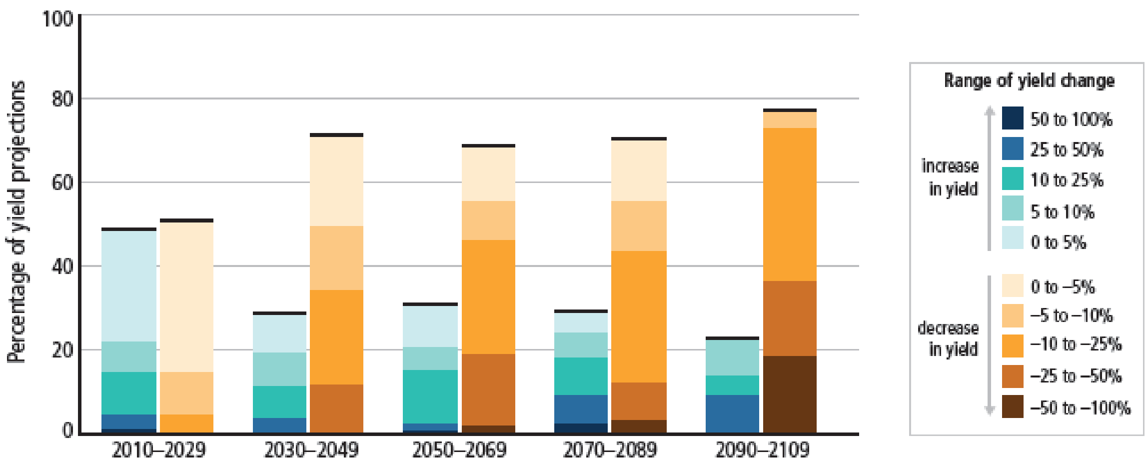


Figure 2.13 **Projection of yield production to beyond the 21st Century** (IPCC, 2014:13)

The continent of Africa is most vulnerable to the negative impact of climate change on food production because many African countries rely on rain to feed crops for their livelihood (Niang *et al.*, 2014:1218). These rain-fed crops are very sensitive to climate-related factors, such as changes in temperature and precipitation, coupled with increased vulnerability to poverty, lack of education, technology and wealth (Nhemachena, 2009:22). Countries in Africa are already facing agricultural problems because of semi-arid conditions, thus by the year 2020 the yield production will reduce by 50%, which will result in food security problems on the continent (Boko *et al.*, 2007:435). Flooding and storms place further strain on food security, which are elevated by climate change events (United Nation Environmental Programme, 2015:5).

A study conducted by Love, Uhlenbrook, Twomlow & Van Zyl (2010:335) analysed data from rainfall, temperature and the discharge station in the Limpopo Basin in Zimbabwe and concluded that the rainfall continues to decrease and, as a result, it is very likely to have a negative impact on crop yield production and rain-feed agriculture. A loss of livestock and a decrease in yield agricultural production are evident in the Eastern African countries, like Somalia, Ethiopia and Kenya who have already experienced re-occurring drought (Debay, 2010:3).

In South Africa, agriculture production in Durban is expected to decrease, especially for the subsistence farmers due to the changes in rainfall and temperature because of climate change (Shamini, 2006:2). Bateman (2009:22) indicated that food production will decrease by 25% in Southern Africa by 2040 or 2050. In addition, Schoeman (2009:8) mentioned that food production across the country will be affected due to the decrease in rainfall and the increase in temperature causing a decrease in maize meal production levels, resulting in food insecurity in the country.

2.3.2 Impact on water

Water plays an essential role in many aspects of life including the industrial sector, the agricultural sector and the natural environment. However, water is under enormous pressure due to climate change and population growth (Swain & Krampe, 2011:16; Murray, Foster & Prentice, 2012:14). The impact of climate change on water projection is well documented, for instance a study conducted by Shrestha, Bach & Pandey (2016:1-13) concluded that ground water is expected to decrease in the short-, medium- and long-term, while rainfall is projected to increase in wet season and decrease in dry season. Similarly, Zhu, Lin, Wang, Zhao & He (2016:687) concluded that, the water resources in the Yellow River Basin in China is expected to decrease from 24% to 30% by the end of the 21st Century under various IPCC scenarios.

The quality and quantity of water, especially drinking water, is projected to be at risk due to climate change factors, such as: (1) increase temperature; (2) increase in pollutants landing in the water bodies due to heavy rainfall; and (3) destruction of water purification plants due to flooding (IPCC 2014:69). In the African context, the influence of climate change on ground water resources is considered to have less of an impact than non-climatic drivers, namely pollution growth, land use change and urbanisation (Niang *et al*., 2014:1217). Drought in the Southern Africa region is expected to occur more frequently (Stringer *et al*., 2009:18).

For example, in countries that experience rainfall between 200mm-500mm per year (Southern Africa and Horn of Africa), the ground water resource will decline and drought and other precipitation anomalies will increase (Niang *et al*., 2014:1217).

South Africa experiences an average annual rainfall of 500mm, which is less than the global average precipitation of 860mm, and therefore is considered as a water scarce country (Tshiala *et al.*, 2011:14, Dennis & Dennis, 2012:417). Climate change will further affect the already scarce water resources in the municipal and industrial water supply (Kusangaya, Warburton, Garderen & Jewitt, 2014:47). The Berg River catchment in the Western Cape is projected to decrease in the annual stream flow by 10% to 20% resulting in less water availability in the river and dams for the residents. Furthermore, the most vulnerable communities are identified as the poor with low income, poor education and poor housing (Lani, 2013:24-25). Similarly, Mgeni River catchment in Durban is projected to decrease by 157 million cubic metres for the period of 2070 to 2100, which will reduce the availability of water for human use and the industrial sector (Shamini, 2006:2).

The Department of Environmental Affairs (DEA, 2012:9) has projected an increase of the average temperature by 1^{o}C to 2^{o}C in the coastal regions and 2^{o}C to 3^{o}C in the interior regions. It is likely to occur in mid-century. Moreover, by the year 2100, the temperature will intensify and increase approximately 3^{o}C in the coastal regions, while the inland regions will experience an increase in temperature of about 6^{o}C to 7^{o}C. As a result, water shortages will occur due to the higher evaporation rate that will affect all sectors dependant on water. Schoeman (2009:8) pointed out that rainfall will decline in most parts of South Africa due to climate change, especially the western part of the country. Also, shortages of potable water will most likely be experienced due to the higher temperatures increasing the evaporation rate.

2.3.3 Impact on health

2.3.3.1 How climate change affects health

Scientific evidence on the impact of climate change on health is increasing (Kjellstrom & McMichael, 2013:1). The health of the population is affected by climate change through direct mechanism (storm, floods and drought) and indirect mechanism, for example vector-borne and water-borne diseases (Patz *et al*., 2014:332). Public health is under continuous pressure due to climate change (Roser-Renouf, Maibach & Li, 2016:1). The Intergovernmental Panel on Climate Change (IPCC) (2014:69) highlights that climate change will have a detrimental impact on human health globally, for example:

- Increase in death due to heatwaves and fires;
- Increase to food-borne and water-borne diseases;
- Higher numbers of malnutrition in poor regions; and
- Increase in vector-borne diseases.

The health impacts of climate change occurs on three pathways, namely direct exposure (heat stress, floods damage and storm), indirect exposure (disease factor, allergens etc.) and social and economic disruptions (food production and mental stress) (Smith, Woodward, Campbell-Lendrum, Chadee, Honda, Liu, Olwoch, Revich & Sauerborn, 2014:716). Furthermore, these exposure pathways occur when there are favourable environmental conditions (water quality, baseline weather, etc.), however, the extent to which the negative impact of climate change affects the population or people depends on the public health measures in place (warning systems, primary health care, social status, etc.) as illustrated in Figure 2.14.

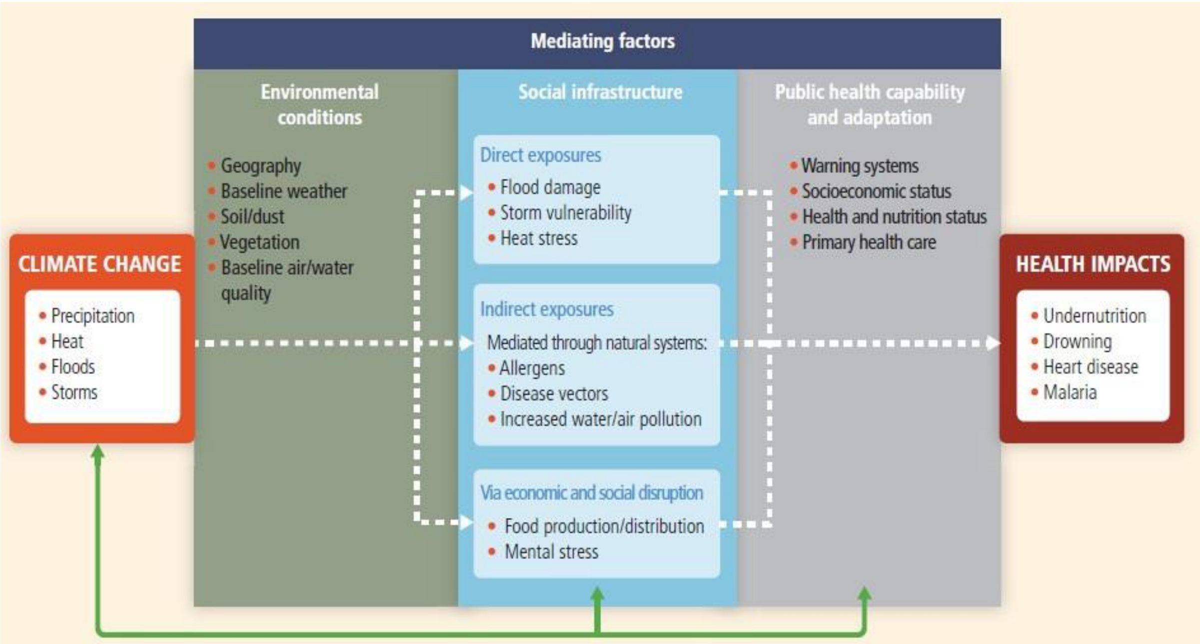


Figure 2.14 **Theoretical models on how climate change affects health**
(Smith *et al*., 2014:716)

In South Africa, Galloway, Manyike, Myers, Tucker & Young (2011:819) explained that the indirect effects of climate change are considered major contributors to the South African national and provincial burden of disease, where the components of health affected are:

- *Infectious diseases*: Water-borne enteric diseases are affected by changes in rainfall as a result of flooding sanitary facilities, which causes cholera, enteroviruses and hepatitis A&B diseases.

- *Mental Health*: This is an indirect consequence of climate change that may be the result of displacement, loss of family members, disabling injury and loss of livelihood, which cause depression, suicide and post-traumatic stress disorders.
- *Chronic diseases*: The increased prevalence of respiratory illnesses, such as asthma, chronic obstructive pulmonary disease, cardiovascular system disease and other respiratory allergic conditions. This risk is due to higher concentrations of air pollutants and the ground level ozone.
- *Malnutrition*: This is due to loss of agriculture and rural livelihood.
- *Women's and children's health*: Climatic changes, such as heat, water insecurity, malnutrition, infectious disease and extreme events will make women and children more vulnerable.
- *Occupational health*: Increased physical and chemical hazards due to higher temperatures cause heat-related illnesses, especially in the agriculture sector and chemical hazards from wildfires and smog.
- *Violence and injury*: The increase in immigration and refugees from neighbouring countries is due to the worsening climate and environmental conditions.

2.3.3.2 Vector-borne and infectious diseases

Vector-borne and infectious diseases are mostly caused by viruses, bacteria and protozoa. These micro-organisms are affected by climate change in three ways as expressed by Patz *et al.* (2014:388):

- Migration of vector from locations or reservoirs;
- Alteration in the development, reproductive and survival of vectors and the pathogens they carry; and
- Prevalence of infections in vectors and changing in the biting rate of vectors increasing transmission to humans.

A study by Thompson, Matamale & Kharidza (2012:838) shows the relationship between climate change and incidence of disease, which revealed that new cases of diseases, such as diarrhoea, respiratory infections, asthma, malaria and meningitis were attributed to climate change parameters. Lotfy (2014:610-612) identified different intermediate hosts (snails, insects and other cold blooded animals) where their mode of disease transmission might be affected by climate change due to the intermediate host being sensitive to changes in temperature, humidity and precipitation. These affect the host survival, distribution and transmission rate. Moreover, Lotfy (2014:610-612) identified the following parasite as being significant due to the impact of climate change: Malaria (mosquito-borne disease), Leishmaniasis (Fly-borne disease) and Bilharzia and Fascioliasis (snail borne infections).

Silver (2008:167) pointed out that, 50 to 100 million people whom reside in tropical and subtropical areas of the world are affected by dengue fever. This is a disease characterised by severe headaches, fever and muscle and joint pain and a more detrimental form of this disease is called dengue haemorrhagic fever. Malaria and dengue are mosquito-borne diseases which are very sensitive to climate change. As a result, incidences of these diseases are expected to increase due to climate change, for example an increase in temperature of 1^{o}C - 2^{o}C will increase the malaria transmission by 39-140% (Yao-Dong, Xian-Wei, Xiao-Feng, Wen-Jun, Hui & Xiao-Xuan, 2013:208-209).

Detailed scientific literature review of journal articles was conducted by Bai, Morton & Liu (2013:1-22) examining the association between infectious diseases and climate changes. The authors concluded that there were observed links between the distribution of infectious diseases (malaria, dengue and Japanese encephalitis) and variability of rainfall, temperature and extreme weather in China. However, there were inconsistencies in the infectious disease distribution in the geographical locations (Bai *et al.* 2013:1-22). Climate change projections on annual dengue incidence in Mexico suggested that there could be an increase of 18%, 31% and 42% of dengue incidence in 2030, 2050 and 2080 respectively, which illustrates an increase in the incidences as the temperature increases (Colón-González, Fezzi, Lake & Hunter, 2013:5).

Wang, Rao, Wu, Zhao & Chen, (2015:779) depicts the climate variable (temperature, precipitation and humidity) and sensitivity to infectious diseases in Anhui Province in China. The study highlighted that infectious diseases, such as Hepatitis A and Dysentery, were sensitive to changes in precipitations and humidity, while Malaria, Influenza and Meningitis were sensitive to changes in temperature and precipitation. Typhoid fever and Schistosomiasis were sensitive to temperature, humidity and precipitations where humidity was the most common climate variable in which all the mentioned infectious diseases were sensitive to. Numerous studies have been conducted illustrating vector-borne and infectious diseases and their susceptibility to climate change variables, for example Nepal (Dhimal, Ahrens & Kuch, 2015:1-31), Africa (Egbendewe-Mondzozo, Musumba, McCarl & Wu, 2011:913-930), Europe (Gray, Dautel, Estrada-Peña, Kahl & Lindgren, 2009:1-12).

Within the South African context, climate change variables and infectious diseases also show possible links. A study conducted by Thompson *et al*. (2012-849) examined health data (10-year period) and meteorological data (21-year period) within five municipal areas in the

Limpopo Province. Thompson *et al*. (2012-849) concluded that there is an increase in the incidence of diseases (diarrhoea 42.4%, respiratory infection 31.3%, asthma 6.6% and malaria 6.5%) with increasing temperature. The study focused on children up to 14 years old. Zvomuya (2012:42) expressed that the incidence increase of Rift Valley Fever (RFV) in the Free State, Northern Cape, Mpumalanga and Eastern Cape is believed to be attributed to climate change due to increased temperature. The emerging cases of Rift Valley Fever (RFV) in the Western Cape maybe attributed to vectors (mosquitoes) carrying the virus to new areas due to the increase temperatures (Zvomuya, 2012:42). The impact of increased temperature on the health of South Africans is insufficiently documented and the future projections of the health impacts have not yet been measured (Wright, Mathee & Garland, 2014:518).

2.3.3.3 Food-borne and water-borne diseases

As the climate change parameter accelerates (increased temperature, elevated extreme rainfall and more frequencies of floods) food-borne and water-borne diseases are more likely to become a public health tragedy (Patz *et al.*, 2014:337). Changes in weather parameters, such as increase in temperature and humidity, decrease and increase in rainfall have a direct impact on the incidence of diarrhoea, as was explored by Moors, Singh, Siderius, Balakrishnan & Mishra (2013-S149) who highlighted that an increase of 13% in diarrhoea incidence was projected to occur in Northern India due to changes in the weather parameters in which the highest incidence was from increased temperature (10%), humidity (1.8%), increased rainfall (1.1%) and decreased in rainfall (0.14%). Moreover, damage of water infrastructure due to heavy rains and flooding can result in the contamination of water to water-borne diseases (Myers, Young, Galloway, Manyke & Tucker, 2011:819)

Similarly, a study conducted in Botswana by Alexander, Carzolio, Goodin & Vance (2013:1202) analysed 30 years (1974-2003) of diarrhoea incidence cases and climate variable data (temperature and precipitation) and revealed an increased peak of diarrhoea incidence in dry months (October) at 20% increase in annual mean of diarrhoea incidences, which may be attributed to increase in temperature and decrease in precipitation. The diarrhoea cases in wet seasons (March) is likely to decline. Cholera is another water-borne diseases, which is sensitive to climate variability (increased temperature) as demonstrated by Traeup, Ortiz & Markandya (2011:4386-4405) who reported a positive relationship between the incidence of cholera and increase in temperature in Tanzania, for instance cholera relative risk increased by 15-29% for a 1^{o}C temperature increase. The effect of climate change on food-borne diseases occurs when foods are exposed to elevated temperature resulting in bacterial growth in the food (Patz *et al*., 2014:339).

2.3.3.4 Heat-related illnesses

A study conducted by Barnett *et al.* (2012:220) looked at different age groups in relation to mortality rate and concluded that older people (>75) experienced higher changes of heat-related deaths. In addition, populations living in the cities are more vulnerable to heat-stress-related health effects because of the absorption of heat by buildings and paved surfaces forming an "urban heat island" (Paz, Negev, Clermont & Green, 2016:3). The linkage between increased temperature and mortality is well documented, placing heat- related mortality as a major concern in public health (Huang, Barnett, Wang, Vaneckova, FitzGerald & Tong, 2011:1681). For instance, Barnett, Hajat, Gasparrini & Rocklov (2012:220) showed a statistically significant increase in the number of deaths (1.6%) when temperature increases. Cardiovascular and respiratory mortality are directly linked to extreme high temperatures (Paz *et al*., 2016:2). High temperature may result in extreme heat causing heat cramps, heat exhaustion, heat syncope and heat stroke due to the inability of the body to control the body temperature (Yoon, Oh, Seo & Kim, 2014:727). Cardiovascular and cerebrovascular diseases increase as temperatures increase (Yoon *et al.*, 2014:727).

Suitable daily average temperature in South China is 26.6^{o}C as reported by Yao-Dong *et al.* (2013:209). Temperature difference of 1^{o}C higher or below 26.6^{o}C increases the mortality rate by 1.9% and cardiovascular disease risk by 3.5% when the temperature increase by 1^{o}C. Similarly, a decrease of 1^{o}C increases the mortality rate by 1.2%, cardiovascular disease risk by 2.5% and respiratory disease risk by 2.0% (Yao-Dong *et al*., 2013:209). The vulnerable populations on the health effects of climate change are individuals with existing medical conditions, such as cardiopulmonary diseases (Rice, Thurston, Balmes & Pinkerton, 2014:512), elderly people (Barnett *et al.* 2012:220; Paz *et al.*, 2016:2) and infants (Zuo, Pullen, Palmer, Bennetts, Chileshe & Ma, 2015:1).

The mean increase of the temperature value of 1.54^{o}C above the threshold value (34^{o}C) increased Parkinson's disease, related to a mortality rate, by 18.6% (Linares, Martinez-Martin, Rodriguez-Blazque, Forjaz, Carmona & Diaz, 2016:3). A study conducted by Yoon *et al.* (2014:725) investigated the burden of disease attributed to climate change using Disability-Adjusted life years (DALYS). The meteorological data for risk factors and databases for incidence and prevalence of diseases were analysed. The study found that the total climate change inducted burden of diseases was 6.85 DALYS/1000 population in 2008, where cerebrovascular diseases accounted for 72.1% of the total burden of diseases.

In the year 2100 a projection of the total burden of disease was estimated to be 11.48 DALYS/1000 population, which is almost twice the 2008 level (Yoon *et al.*, 2014:725).

2.4 CONFERENCE OF PARTIES (COP) 21: PARIS

Conferences of the Parties (COP) are annual meetings held every year in a specific country to discuss the progress made on the aim of the United Nations Framework Convention on Climate Change (UNFCCC). The main aim is to stabilise the GHG emissions concentration in order to avoid emissions levels that hampers the natural climate system (Roberts, 2016:9). The UNFCCC was first incorporated at the United Nation Head Quarters in New York in 1992 and two years later (1994) it was established, and currently has 197 members (Roberts, 2016:9).

COP 21 was held in Paris from the 30th November to the 11th of December 2015 (UNFCCC, 2015). COP 21 is regarded as the most successful conference focussing on climate change mitigation. For the first time, the international community comprising of different countries (including China and United States for the first time) agreed to take measures to limit the global temperature to below 2^{o}C and cap the temperature level at 1.5^{o}C (Nandy, 2016:47). The progress of the agreements in COP 21 was based on the foundation work conducted during COP 17 in Durban, which emphasised the need for a new legally binding agreement among the world's governments by the end of the second commitment of the Kyoto protocol in 2020 (Roberts, 2016:9).

According to the UNFCCC report, the Paris Agreement reached its onset of enforcement on the 5th of October 2016 and it was officially imposed on the 4th of November 2016 (UNFCCC, 2016). To date, approximately 177 countries have signed the Paris Agreement in which 16 countries have already submitted their ratification plans (Upton, 2016:60). The main agreements of the COP 21 endorsed commitments including:

- To limit the global temperature to well below 2^{o}C and work towards a temperature cap of 1.5^{o}C (United Nation, 2015:3; Roberts, 2016:10);
- To establish Nationally Determinant Contributions (NDC) in which every country is required to submit a new NDC every five years in which they commit themselves to achieve the contents in their NDC including GHG emission reduction (United Nation, 2015:2-6; Nandy, 2016:48; Roberts, 2016:10);

- For developed countries to provide financial assistance to the developing countries to an amount of $100 billon by the year 2020 (Kampmark, 2015:37);
- To establish a global goal of adaptation, as a way of achieving global response to climate change to protect people, ecosystems and livelihood, and for Parties to agree to enhance cooperation in adaptation as stipulated in the Cancun Adaptation Framework (United Nation, 2015:9-10).

2.5 RESPONSE TO CLIMATE CHANGE BY SOUTH AFRICA

2.5.1 Long-term mitigation scenarios and strategic options for South Africa

The production of energy in South Africa is largely dependent on fossil fuel. In fact, 75% of the primary energy supply is from coal and over 90% of electricity production. Furthermore, energy-related emissions make up 78% of the South African GHG inventory, making the energy sector an important consideration in the mitigation of climate change emissions (Winker, 2006:1). South Africa had contributed 1% of the world total global emissions of 440 Mt CO_2 equivalent, while the rest of the world produced about 49 000 Mt CO_2 equivalent mainly from deforestation and energy production (Scenario Building Team, 2007:4). When South Africa is compared with other countries in terms of emissions, for instance per capita (population of the country is divided by emissions) and per emission intensity (population is divided by GDP), it shows that in South Africa emissions per intensity is higher than other developing countries and in terms of per capita, it is higher than in India and China (Figure 2.15 and 2.16) (Scenario Building Team, 2007:4).

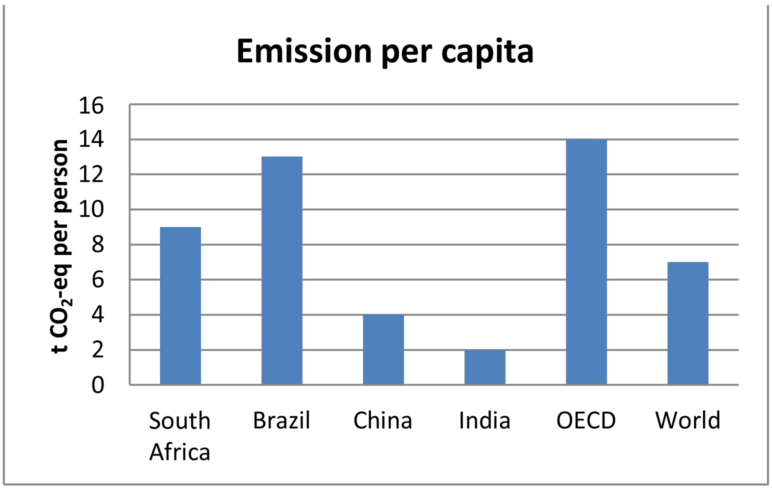


Figure 2.15 **Emission per capita (population of country divided by emissions)**
(Scenario Building Team, 2007:5)

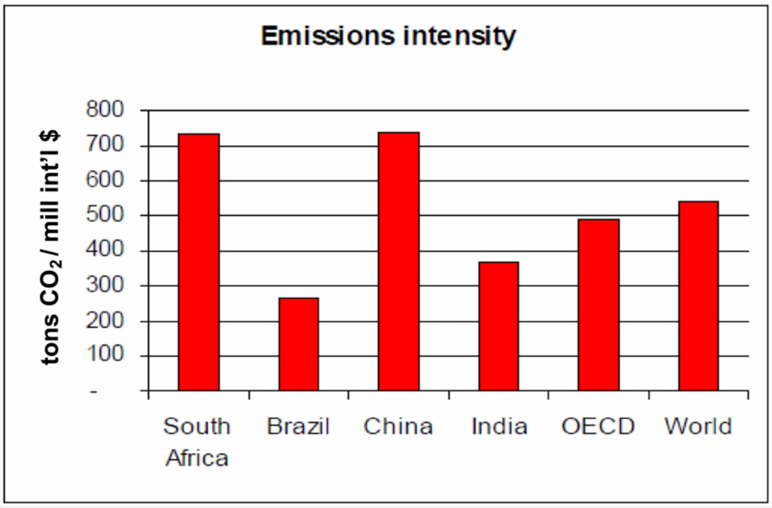
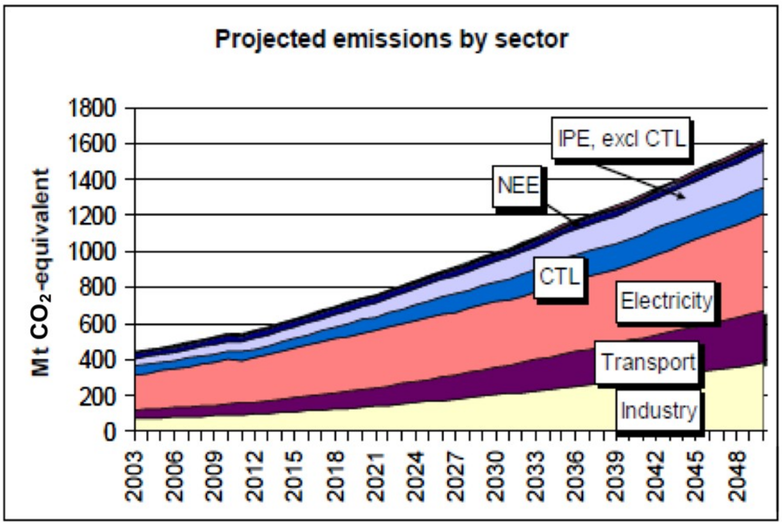


Figure 2.16 **Emission per intensity (population of country divided by GDP)**
(Scenario Building Team, 2007:5)

In 2006, the South African Cabinet initiated a process of examining the country's GHG mitigation potential. The outcome of the process was the formation of multiple skilled team called the Scenario Building Team (Scenario Building Team, 2007:1). The Scenario Building Team (SBT) consisted of experts from important sectors across business, government and society (Winker, Hughes, Morquard, Haw & Merven, 2011:5819).



CTL=Coal to Liquid IPE=Industrial Process Emissions NEE=Non-Energy Emissions

Figure 2.17 Growth without Constraints (GWC) for the period 2013-2050
(Scenario Building Team, 2007:8)

Two scenarios were identified by SBT of which Scenario One was based on growth without constraint that is used as a reference for South Africa (Scenario Building Team, 2007:7). The growth without constraints assumes that the country will continue to grow without any measures to reduce carbon emissions (Winkler *et al.*, 2011:5819). Figure 2.17 presents the growth without constraints scenario where it can be seen that the emissions will be four times greater (Scenario Building Team, 2007:8).

Scenario Two is the required by science scenario, which assumes that if South Africa had all the resources and technology for global mitigation efforts, then the emissions would peak in 2020 at around 470 Mt CO_2 equivalent and then decline (Scenario Building Team, 2007:10). This can only be achieved if South Africa takes -30 to -40% burden of the required global reduction from 2003 levels by 2050. Figure 2.18 shows that Growth without Constraints (GWC) grows exponentially, while growth required by science (RBS) peaks in 2020 at 470 Mt CO_2 equivalent and then declines. In order for Scenario Two to be successful, four strategies are needed, (1) start-now strategy that suggests action to save money; (2) scale-up strategy that suggests further strengthening of start-now strategy by adding more wedges with positive cost; (3) market strategy that includes the replacement of the former strategies and introduces tax and an incentive package; and (4) reach-the-goal strategy emphasising future technologies and behavioural changes (Scenario Building Team, 2007:10-14).

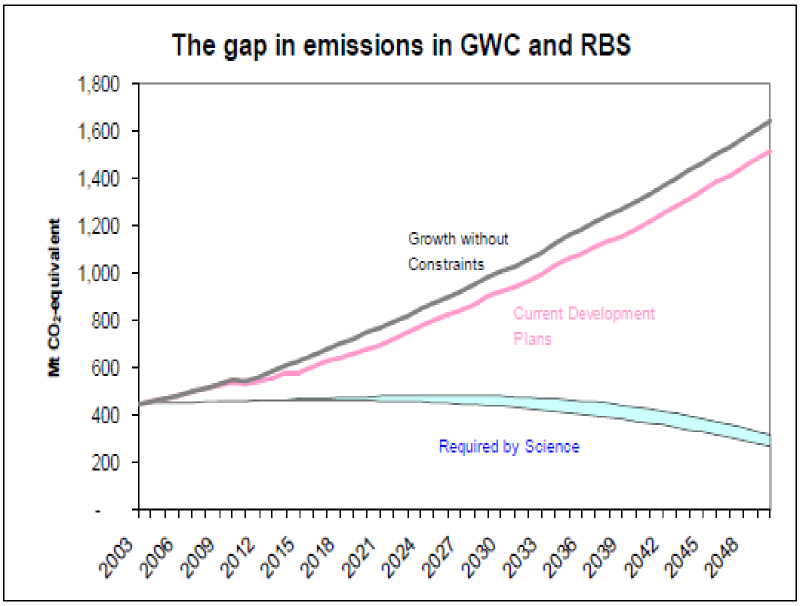


Figure 2.18 **Growth without Constraints (CWC) and Required by Science (RBS)** (Scenario Building Team, 2007:11)

2.5.2 National Climate Change Response White Paper

The South African Government accepted that GHG is responsible for climate change and acknowledges that the effect of climate change is detrimental to the sustainability of the country. Thus, the South African Government is committed and ready to work with the international community to tackle climate change (DEA, 2012:9). In 2004, the former President of South African, Mr. Thabo Mbeki, announced that the country will implement measures to allow GHG emission to decline below its “business as usual” trajectory by 34% in 2020 and 42% in 2025, on condition that support is received from the developed countries (DEA, 2012:25).

In 2011, the National Climate Change Response White paper was developed and was based on the principle of various laws and guidelines, such as Section 24 of Constitution of South Africa, National Environmental Management (NEMA) Act, National Development Plan, the UNFCCC framework and the Millennium Declaration, among others (Adeleke *et al*. 2014:6). The White Paper outlines areas of mitigation, adaptation and skill development as areas for intervention (Moyo, 2016:136).

The overall objective of the White Paper is to “manage climate change impacts through interventions that build and sustain South Africa’s social, economic, environmental flexibility, and emergency response strategy”. Furthermore, the paper also mentions the need to stabilise the country’s GHG contribution in the atmosphere to a level that will not be detrimental and within a time frame that will also allow social, economic and environmental development to proceed successfully (DEA, 2012:9).

The White Paper mandated the development of climate change adaptation strategies into different government sectors (DEA, 2012:17-24). As a result of the mandated requirement of the White Paper, the Department of Environmental Affairs (DEA, 2013:8) initiated a research programme titled, “The Long-Term Adaptation Scenario (LTAS) Flagship Research Programme”, to research the adaptation strategies scenarios for the four (4) government sectors, namely water, health, biodiversity and agriculture and forestry. A brief summary discussion on water and health are presented here.

2.5.2.1 Long-term Adaptation Scenarios (LTAS): Water

The water scenario begins with South Africa’s strategic planning for water resources at different levels, such as the national water resource system, water management area and the municipal sub-catchment (DEA, 2013:14). The water sector uses reconciliation studies as a system for water planning, which is based on historical climate and hydrological variability in water infrastructure planning (DEA, 2013:18). The impacts of climate change on the water sector are water quality, water service, runoff, infrastructure and the impact on human security (DEA, 2013:29-31). Possible adaptation measures are discussed in relation to the water resource planning framework and measures in the reconciliation studies and the scenario concludes an indication of the areas that require further research (DEA, 2013:29-31).

2.5.2.2 Long-term Adaptation Scenarios (LTAS): Health

The current challenges facing the South African health system are the quadruple burden of diseases, such as Human Immunodeficiency Virus (HIV) and Acquired Immune deficiency syndrome (AIDS), maternal and child mortality, non-communicable diseases and violence, injury and trauma (DEA, 2013:11-12). The Department of Health (DoH) identified nine (9) health risks as stipulated by the National Climate Change and Health Adaptation Plan. These health risk are: heat stress, vector-borne diseases, food insecurity, hunger and malnutrition, natural disaster, air pollution, communicable diseases, non-communicable diseases, mental health and occupational health (DEA, 2013:29-31). Adaptation measures for the impact of climate change on health and possible research recommendations are based on the five major adaptive measures that include vulnerability assessment, monitoring and surveillance, access data, multi-sectoral collaboration and adaptive capability (DEA, 2013:32-35).

2.5.3 South African carbon tax

Carbon tax is a tool for carbon pricing that is directly linked to the carbon emissions produced, which is expressed in tonne carbon dioxide equivalent (t CO_2e). Carbon tax is an economic tool that can be used for emission reduction in a cost-effective manner (World Bank, 2016:1). Carbon tax can be introduced as either a new instrument or along with another carbon pricing instrument, energy tax. Many countries worldwide have introduced direct carbon tax, such as Chile, Costa Rica, Denmark, France, United Kingdom, etc. (World Bank, 2016:1).

The idea of carbon tax in South Africa was introduced in 2010 in the form of a discussion paper for public comment "reducing greenhouse gas emission: the carbon tax option" (Pousson, 2012). In May 2013, the National Department of Treasury published a policy document for comment titled, "Carbon tax policy paper - reducing greenhouse gas emissions and facilitating the transition to green economy". The national response white paper also supports the carbon tax as a regulatory measure for mitigation of carbon emissions (National Treasury, 2013:7).

Three options for the implementation of carbon price on carbon tax was suggested: (1) Tax applied to measure GHG directly; (2) Fossil fuel input on tax; and (3) tax levied on energy out-out. From these options, the "fossil fuel input on tax" was considered practical and appropriate, because of the availability of emission factors to accurately quantify the CO_2e emissions across different sectors and processes. The carbon tax will only include Scope 1 emissions from fuel combustion, gasification and non-energy industrial processes (National Treasury, 2013:12-13).

The carbon tax is expected to be implemented in January 2017 at a cost of R12O per t CO_2e. However, considering tax-free allowances in the carbon tax policy, the actual carbon tax price will range from R6 to R48 per t CO_2e (Klingelhofer, 2016:10; Strydom, Croker & Gilfillan, 2016). The sectors affected by the carbon tax are the sectors falling in the listed activities as per section 29(b) of the National Environmental Management Act: Air Quality Act, 2004 which are (Strydom *et al.*, 2016):

- Energy industries (petroleum refineries, electricity and heat production);
- Manufacturing and constructions (including chemicals);
- Road transport, railways and waterborne navigations;
- Coal mining, storage and processing;
- Processing of soil fuels;
- Leakage of natural gas during coal mining (methane);
- Flaring during refinery; and
- Mineral and chemical production.

2.6 CONCLUSION

Climate change is the biggest threat facing the world today (Goklany, 2009:69; Kumaresan *et al*., 2011:201; Bell, 2011:804; Regan *et al*., 2012:1). The majority of scientists worldwide concluded that climate change is caused by human activities as a result of Greenhouse Gases (GHG) being emitted into the atmosphere (Filiberto *et al.*, 2009:19; Mertz *et al*., 2009:743; Tseng *et al*., 2009:124; Kumaresan *et al*., 2011:201; Perlmutter & Rothstein, 2011:66). The produced greenhouse gases (GHGs) cause greenhouse gas effects that result in an increase in temperature (Cubasch *et al.*, 2013:126). Carbon footprint evaluates the emissions of greenhouse gases (GHGs) produced by a person, organisation, process or activities (Rossi *et al*., 2016:97).

Temperature and precipitation are important factors in climate change (Chenkova & Nikolova, 2015:S381). Many countries worldwide are reporting an increase in average temperatures and fluctuating precipitations (Hidalgo *et al*., 2013:94-112; Chenkova & Nikolova, 2015:S381-S390). Climate change has an impact on various as aspects of life, for example agriculture and food security (Debay, 2010:3; Thornton *et al.*, 2011:117; Singh *et al*., 2015:119), impact on water (IPCC 2014:69; Niang *et al*. 2014:1217; Shrestha *et al.*, 2016:1-13) and impact on health

(Thompson *et al*., 2012:838; Alexander *et al*., 2013:1202; Patz *et al.*, 2014:337). In view of the negative impact of climate change, Ekurhuleni Health District as an organ state should consider its contribution to reducing GHG emissions in the light of increasing health of their constituent. It was, therefore, appropriate to ask the questions: (1) What is the carbon footprint of Ekurhuleni Health District and Provincial Clinic employees? (2) What is the status of knowledge and perceptions on climate change among managers and operational employees?

The United Nations Framework Convention on Climate Change (UNFCCC) mandate is to facilitate the stabilisation of the Greenhouse Gas (GHG) emissions concentration in order to avoid emission levels, which hamper the natural climate system (Roberts, 2016:9). Regarding this, the international community, compromising of different countries (including China and United States for the first time), have agreed to take measures to limit the global temperature to below 2^{o}C and cap the temperature level at 1.5^{o}C in the Conference of the Parties (COP) 21 held in Paris from the 30^{th} November to 11 December 2015 (UNFCCC, 2015; Nandy, 2016:47).

In South Africa context, Mr. Thabo Mbeki the former president of South Africa in 2004 had announced that, South Africa will implement measures to allow the greenhouse gases (GHGs) emissions to deviate by 34% in 2020 and 42% in 2025 below its “business as usual” trajectory (DEA, 2012:25). To date, the South Africa government have introduced policies and guidelines to mitigate climate change such as: (1) National Climate Change Response White Paper, (2) South Africa Carbon Tax and (3) Long Term Adaptation Scenarios (DEA, 2013:8; National Treasury, 2013:7; Adelekee*t al*. 2014:6).

Chapter 3
METHODOLOGY

A combination of quantitative and qualitative research designs were used in this study. These research designs focus on different aspects in the study and are not intended for correlation purposes. The quantitative study design was used to determine the first objective of the study, which was to estimate the carbon dioxide equivalent emissions of Ekurhuleni Health District office and Provincial Clinic employees. The qualitative research design was used to establish the knowledge and perception of climate change among management and operational employees within the District Office and Provincial Clinics. These research designs are discussed separately and in more detail below

3.1 QUANTITATIVE STUDY DESIGN FOR CALCULATING CARBON FOOT-PRINTS

According to Mark (1996:210) quantitative research involves using numerical data to analyse a phenomenon under investigation and includes counting, using standard deviations and analysing data using complex procedures. Daly (2003:192) concurs that quantitative studies investigate phenomenon by using a numerical approach, which require variables that are arithmetical to form a bases of analysis.

The term, “carbon footprint”, is defined as the direct or indirect release of the total amount of carbon dioxide by activities or over the life stage of products (Wiedmann & Minx, 2008: 29; Kenny & Gray, 2009:1). Carbon footprint is used to describe the greenhouses gases companies and individuals produce (Tjandra, Ng, Yeo & Song, 2015:4183). Carbon dioxide equivalent (CO_2e) is a unit of measurement that refers to the global warming potential (GWP) of greenhouse gases (Kenny & Gray 2009:1; Tjandra *et al.*, 2015:4183).

Various different carbon footprint quantification studies of services and products have been conducted, for example the carbon footprints associated with procurement (Alvarez & Sergio, 2015:159-166), travel activities of a university’s sport team (Dolf & Teehan, 2015:244-255), tourism sector (Cadarso, Gómez, López & Tobarra, 2016:529-237), universities (Ozawa-Meida, Brockway, Letten, Davies & Fleming, 2013:185-198), office environment (Tjandra *et al.*, 2015:4183) and the South African Police Service (Smith, 2011:1-98).

3.2 CURRENT METHODS FOR CARBON FOOTPRINT CALCULATIONS

Methodologies available to quantify carbon footprints of products and services include: (1) Greenhouse Gas Protocol (GHGP) calculation tools (GHGP, 2012g); (2) Department of Environmental Forest and Rural Affairs (DEFRA) governmental conversion factors (DEFRA, 2015b); and (3) International Standard Organization (ISO) 14067: 2013 Greenhouse Gas Emissions (Wu, Xia & Wang, 2015:143). These methodologies are discussed below.

3.2.1 Greenhouse Gas Protocol (GHGP)

GHGP was formed in 1998, after collaboration between the World Business Council for Sustainable Development (WBCSD) and World Resource Institute (WRI) for the development of international guidelines for accounting and reporting GHGs (GHGP, 2012e). WBCSD was the result of the collaboration of 200 international companies with a passion for conducting business in a sustainable way. The mission of the WBCSD is to promote innovation, eco-efficiency and social responsibility (GHGP, 2012f).

Moreover, the WRI was created in 1982 as an independent organisation to advise on environmental issues after the negative effects of climate change, deforestation and desertification were perceived in the1960s and 1970s (WRI, 2012). The need for a climate change policy initiated a working cooperation between WBCSD and WRI for the development of an international standard for corporate GHG accounting and reporting, which was first published in 2001. Thereafter calculation tools were made available for companies to use free of charge (GHGP, 2012e). The GHG Protocol is a guideline tool that is used internationally for quantification of greenhouse gas emissions of governments and businesses (GHGP, 2012e). Therefore, in this study the GHGP tools are used in order to allow other researchers to replicate this study.

3.2.2 Department of Environment Forestry and Rural Affairs (DEFRA)

Another method is presented by DEFRA, which is a United Kingdom (UK) government department responsible for policy on and regulation of environmental issues (DEFRA, 2015a). Tauringana and Chithambo (2015:425) explained that the United Kingdom had taken steps to address climate change by launching a climate change programme that resulted in the drafting of the Climate Change Act of 2008. The UK Climate Change Act outlines how the country will reduce GHG emission by 80% below the 1990 levels by 2050 (Ozawa-Meida *et al*., 2013:185). In addition, the Act highlights the need for developing guidelines for calculating GHG emissions, subsequently a guideline was published the 2009 by DEFRA (DEFRA, 2009:3).

The published guideline titled, *Guidance on how to measure and report your greenhouse gas emission*, makes reference to organisations and companies to make use of the emission factors provided by DEFRA, as well as the DEFRA-based conversion factors for UK emissions (DEFRA, 2009:3). This study uses some of the DEFRA greenhouse gas conversion factors to calculate the carbon footprints of the Ekurhuleni Health District office.

3.2.3 International Standard Organisation (ISO) 14067 of 2013

The ISO 14067 of 2013 Greenhouse Gas Emissions was first published in May 2013 as a technical specification and was developed by more than 100 professionals from 30 different countries (Wu *et al.*, 2015:143). The ISO 14067 of 2013 identifies three areas companies need to pay attention to, in order to develop a GHG gas inventory (Smith, 2011:24), namely:

- Setting boundaries that include operational and organisation boundaries;
- Quantification; and
- Reporting.

3.3 ORGANISATIONAL AND OPERATIONAL BOUNDARIES

It is essential to set boundaries when determining GHG emissions. According to the GHGP (2012d:16-24), there are two types of boundaries which should be considered and set, namely organisation and operational boundaries.

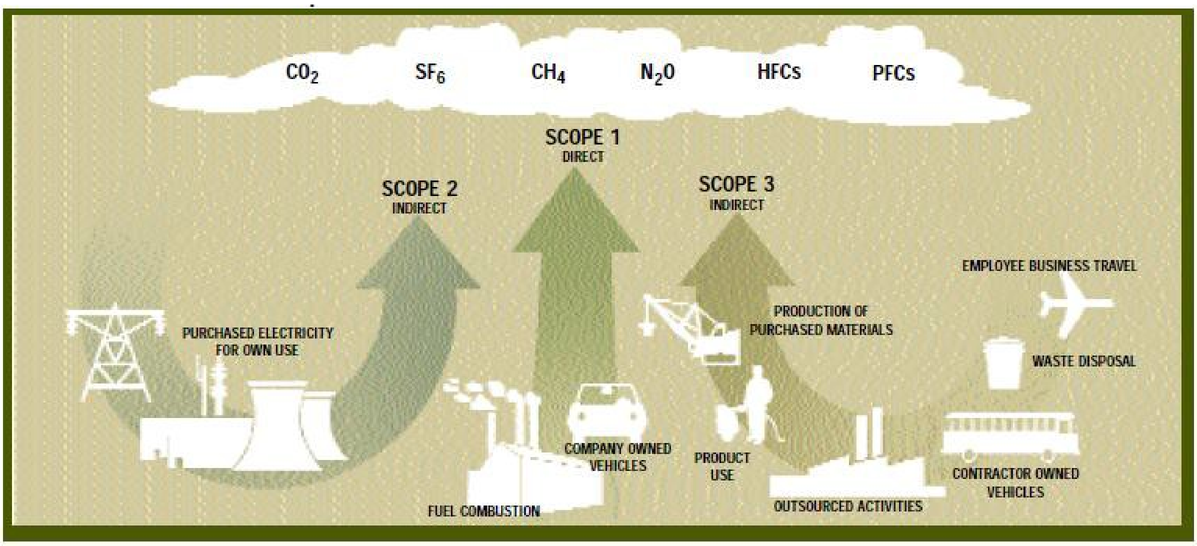


Figure 3.1 **Overview of scopes and emissions** (GHGP, 2012d:26)

In terms of organisational boundaries, the study uses the "control approach", the reason being that GDoH has direct financial control over operations in provincial clinics and

GDoH has the ability to implement policies in the operation of activities within these clinics (M. Thamsanqa, personal communication, 2 September 2014). The GHGP (GHGP, 2012d:25) suggests three scopes that need to be considered in determining emissions, for example Scope 1 accounts for direct GHG emissions such as that by company owned vehicles. Scope 2 covers the indirect GHG emissions from purchased electricity and Scope 3 covers other indirect emissions, such as outsourced activities and production of purchased material, as illustrated in Figure 3.1.

In terms of operational boundaries in the current study, Scope 1 accounts for the direct GHG emissions generated from GDoH government fleet vehicles, Scope 2 covers the indirect GHG emission from purchased electricity and Scope 3 covers other indirect emissions, such as office paper, ICT and air conditioners (Table 3.1).

Table 3.1 **Scopes of operational boundaries included in this study**

Scope	**Examples in this study**
Scope 1	Direct emissions: Government fleet vehicles
Scope 2	Indirect emissions: Purchased electricity for facilities
Scope 3	Indirect emissions: Office paper, ICT and air conditioners

3.4 SAMPLING

The facilities listed in Table 3.2 were included in the study. The criteria used to investigate these facilities were based on the premises that the department controls and owns these health facilities. In order to structure the research by control approach (as discussed in section 3.3), only the clinics controlled by the Provincial Gauteng Department of Health (GDoH) was included in the study. A list of all the clinics within the Ekurhuleni Metropolitan Municipality (EMM) was obtained, thereafter all the GDoH provincial clinics in the list were selected. Furthermore, in order to obtain the latest information in connection with GDoH provincial clinics, several personal communications with officials was conducted to confirm the final ownership of the clinics.

In order to estimate the carbon footprint of Ekurhuleni Health District and provincial clinics employees, it is essential to identify and quantify the different carbon variables available in the facilities. In this study only five years (2010-2014) carbon variables data were provided, as a result only five year impact assessment for carbon footprint was conducted.

Table 3.2 **Provincial clinics/offices controlled and owned by Gauteng Department of Health** (D. Chiloane, personal communication, 28 March, 2012)

Name of facility and location	Sub-district
1. District Office (Germiston)	South 1
2. Isabella Clinic (Kempton Park)	North 1
3. Esangweni Dental and M.O.U (Tembisa)	North 2
4. Northmed Clinic and Dental (Benoni)	North 2
5. Mary Moodley Memorial Community Day Centre (Benoni)	North 2
6. Jabulanid Dumani Community Centre (Vosloorus)	South 1
7. Magagula Clinic (Katlehong)	South 2
8. Phola Park Dental and M.O.U. (Thokoza)	South 2
9. Ramokonopi Community Health Centre (Katlehong)	South 2
10. Phillip Moyo Dental and M.O.U. (Etwatwa)	East 1
11. Andries Radisela Clinic (Kwa-Thema)	East 2
12. Nokuthela Ngwenya dental and M.O.U. (Nigel)	East 2
13. Kwa-Temba Dental and M.O.U. (Kwa-Temba)	East 2

M.O.U. = Maternity Output Unit

The following carbon data sets were collected in the facilities listed in Table 3.2:

- Government fleet vehicles;
- Electricity consumption;
- Office paper;
- Information and communication technology (ICT) equipment; and
- Air conditioners.

3.5 DATA COLLECTION

Prior to data collection, a research proposal was approved and ethical clearance was obtained from both Ekurhuleni Ethics Committee (project number: 2013-09-2013-01) and the University of South Africa (UNISA) Ethics Committee (reference number 2013/CAES/030). Additional permission to access data was obtained from the Chief Director of the District office. These documents are presented in Appendix A, B and C. The collection procedure of each carbon variable in this section is structured per scope (1, 2 & 3) in accordance with the Greenhouse Gas Protocol procedure as presented in Table 3.3.

Table 3.3 **Collected carbon data sets and respective sources**

Scopes	Carbon data sets	Source
Scope 1	Government fleet vehicles (kilometres travelled and fuel consumed)	Transport Unit
Scope 2	Kilowatts of electricity consumed	Finance Unit
Scope 3	Office paper utilised	Procurement Unit
	Information and communication technology (ICT)	Information technology (IT) Unit
	Air conditioners	Various facilities physical counting of the number of air conditioners

3.5.1 Government fleet vehicles (Scope 1)

Data on fuel consumption (petrol & diesel) and distance travelled by GDoH government fleet vehicles were collected from the Transport Unit within the Ekurhuleni Health District Office for the period of five years (January 2010 to December 2014). The government fleet vehicles were assigned to be used for rendering health services by officials in Ekurhuleni Health District Office and provincial clinics. Two meetings on different days, lasting approximately one hour, were conducted with the transport officer. The aim of the first session was to discuss the availability of carbon data variables for vehicles and the format of the data (soft or hard copy). In the second meeting, all the carbon variable data in form of hardcopies were collected and the soft copy information was sent by email by the transport officer to the researcher.

Government fleet vehicle data received from the transport unit for 2010, 2011 and 2012 was in hardcopy form. This information was converted from hardcopy to soft copy by manually capturing the data into Microsoft Excel. The vehicle asset register containing information of the make, model and manufacturing date of each available vehicle was captured into Microsoft Excel.

3.5.2 Electricity (Scope 2)

At the time of the study there were twelve provincial health facilities (clinics) in Ekurhuleni (Table 3.2) and this number excludes the district office. The Finance Department at the district office is responsible for paying electricity bills of provincial clinics and a portion of the district office. The electricity consumption (in kilowatts) by the health facilities were obtained from the municipal invoices supplied by the Finance Unit within the Ekurhuleni Health District Office.

The District Office at Catlin Street is co-habitant to three different departments, namely Gauteng Department of Health (Ekurhuleni health district), Department of Social Development and the South Africa Social Security Agency (SASSA). Each department is responsible for paying electricity bills of the District Office four times a year, therefore, only four months of electricity consumption information of the District Office was available for each year. In order to compensate for the eight (8) missing months data for the District Office each year, it was necessary to extrapolate the missing months by averaging the available kilowatts information, as discussed in section 3.6.2.

In some cases the provincial clinics shared the same building structure with local clinics. Therefore, the total electricity consumed is reported in one invoice. In cases where the building structure is shared between provincial and local clinics, the responsibility of paying the electricity bills resides with the local government. As a result, the municipal invoices of these shared building structure was not available at the Finance Unit.

The electricity consumption data for only three facilities were obtainable, namely the District Office, Nokuthela Ngwenya Clinic and Northmead Clinic. Due to the data limitation for the ten facilities, it was necessary to extrapolate the missing information of the facilities by averaging the available data to amend the missing information (see section 3.6.2).

3.5.3 Office papers (Scope 3)

The Procurement Department at the District Office is responsible for the procurement of printing paper. The paper is supplied by Sappie and distributed to all the health facilities shown in Table 3.2. The printing paper is centrally stored in the procurement area. The Procurement Department keeps records on the total number of boxes of office printing paper supplied and distributed to different health facilities by means of a system named, “Bin Card”. The Bin Cards were obtained from the procurement office for the period of April 2011 to December 2014 and this information was captured in Microsoft Excel.

3.5.4 Information and Communication Technology (ICT) (Scope 3)

An inventory containing the number of Central Processing Units (CPUs), monitors, printers and laptops were obtained from the Information Technology Unit. Analysis of information, such as the name of the employees, office and personnel employment number did not form part of this study.

3.5.5 Air conditioners (Scope 3)

The number of air conditioners available in the facilities were determined by means of a physical inventory. In the case where offices were closed at the time of the survey (District Office), the total number of closed offices were surveyed and it was assumed that each office would have at least one air conditioner.

Five facilities were surveyed for the total number of air conditioners available, which were:

- District Office: 88 air conditioners (HFC-23 type);
- Nokuthela Ngwenya: 62 air conditioners (R410A type);
- Northmead: 9 air conditioners (HFC-23 type);
- Magagula: 4 air conditioners (HFC-23 type); and
- Kwa-Themba: 4 air conditioners (HFC-23 type).

However, the air conditioner data of the eight provincial clinics was not obtainable. Therefore, in order to obtain a complete air conditioner carbon footprint of the provincial clinics, it was necessary to extrapolate the missing information by averaging the available air conditioner data. It was assumed that the type of the missing numbers of air conditioner refrigerants are likely to be HCF-23.

3.6 DATA ANALYSIS

The data analysis procedure in this section is structured per scope (1, 2 & 3) in accordance to the GHGP structure. Scope 1 data permits a more robust and multi-method analysis approach due to data availability, whereas scope 2 & 3 data was insufficient to allow suitable comparison approach. Therefore, each scope is discussed in more detail to follow:

3.6.1 Carbon emission from government fleet vehicles (Scope 1)

Carbon emissions from government fleet vehicles were calculated from information, such as kilometre travelled and fuel, both petrol and diesel, consumed. The emissions were calculated by multiplying kilometre travelled and fuel consumed by respective emission factors published by DEFRA for each specific year in question. In 2010 and 2011, no emission factors were available and default emission factor values were used by averaging the available emission factors from year 2012, 2013 and 2014, as presented in Table 3.4.

In order to determine a vehicle's carbon footprint, two methodologies were used, both methodologies necessitate vehicle information breakdown per fuel type and engine size. The first applied a DEFRA methodology where 100% mineral petrol and diesel emission factors were multiplied by fuel used to calculate carbon dioxide equivalent (CO2e) emissions for fuel consumed. CO_2e emissions based on the size of the engines was calculated by multiplying the vehicle kilometre travelled with the engine size emission factor of the vehicles (small, medium or large) (Table 3.4).

Table 3.4 **Emission factors to quantify carbon footprint of government fleet vehicles**

	Emission factor			
Variable	**2010/2011**	**2012**	**2013**	**2014**
Fuel (petrol & diesel) consumed in kg CO_2e/L	Petrol: 2.3082 Diesel: 2.6736 Ave. emission	Petrol: 2.3144 Diesel: 2.6769 Source: DEFRA 2015	Petrol: 2.3104 Diesel: 2.6705 Source: DEFRA 2015	Petrol: 2.2999 Diesel:2.6691 Source: DEFRA 2015
Kilometres travelled in kg CO_2e/km (by engine size)	Small: 0.14348 Medium: 0.1765 Large: 0.23184 Ave. emission	Small: 0.14297 Medium: 0.17755 Large: 0.23563 Source: DEFRA 2015	Small: 0.14048 Medium: 0.17475 Large: 0.22941 Source: DEFRA 2015	Small: 0.14701 Medium: 0.1772 Large: 0.23049 Source: DEFRA 2015
Kilometres travelled from car manufacturer in g CO_2e/km	Obtained online from car manufacturer	Obtained online from car manufacturer	Obtained online from car manufacturer	Obtained online from car manufacturer

Ave.=Average *Note*: See Table 3.7 for references

Manufacturer CO_2e emission calculations were determined by multiplying the vehicle kilometres travelled by the vehicle manufacturer specific emissions factors. An average CO_2e emissions (obtained by averaging the available data from all the months) was used in months, where no source data was available, including February 2010, March 2010, June 2010, July 2011 and August 2012. The breakdown description of vehicles information is explained in chapter four (section 4.1.8)

Table 3.5 presents the number of vehicles where fuel data were not available; this necessitated the use of average CO_2e emissions for each vehicle calculated from available fuel emissions (t CO_2e) divided by the number of vehicles for that specific year in question. Averaged t CO_2e emissions were also used for the months with missing data (February 2010, March 2010, June 2010, July 2011 and August 2012) derived from the available fuel emissions (t CO_2e) for 5 years (2010 - 2014) as indicated in Table 3.6.

Some vehicles had missing make and model information (Table 3.6), which renders it difficult to identify fuel type and emission factor to be used (either petrol/diesel emission factor) when calculating the fuel carbon emissions. Therefore, in these cases, a petrol emission factor was used (Table 3.4) as a default, because it is deemed more likely for the fleet vehicle to be using petrol than diesel, considering the existing data percentage of the vehicles available. Table 3.7 presents the manufacturer emission factors and default emission factors used in the calculation of manufacturer CO_2e emissions. Where manufacturer emission factors were not avaialble, DEFRA engine size emission factors were used as a default.

The second methodology used the GHG Protocol Tool for Mobile Combustion (version 2.6) to determine the carbon footprint of government fleet vehicles in terms of fuel, both petrol and diesel, consumed and kilometre travelled. This was done by completing Microsoft Excel spreadsheet provided by the GHG Protocol. The vehicle activity level in this study is defined as the number of days in which the vehicles were used to render health services (vehicle used days) and the number of days the vehicles were not used (vehicle idle days). The vehicle use days and associated CO_2e emissions was calculated, by multiplying the fuel consumed by a respective emission factors published by DEFRA (Table 3.4).

Table 3.5 **Number of vehicles (*) in which an average fuel emissions (t CO2e) was used (#) per month for that specific year due to data unavailability.**

Year	**January**	**February**	**March**	**April**	**May**	**June**	**Ave. (t CO_2e)**
2010	12 vehicles* (total 101)	n/a	n/a	15 vehicles* (total 106)	2 vehicles* (total 105)	n/a	0.200#
2011	10 vehicles* (total 115)	6 vehicles* (total 115)	1 vehicle* (total 118)	13 vehicles* (total 118)	6 vehicles* (total 118)	8 vehicles* (total 116)	0.242#
2012	11 vehicles* (total 118)	3 vehicles* (total 117)	3 vehicles* (total 116)	15 vehicles* (total 116)	31 vehicles* (total 111)	1 vehicle* (total 75)	0.266#
2013	4 vehicles* (total 72)	0 vehicle* (total 70)	5 vehicles* (total 70)	4 vehicles* (total 69)	1 vehicle* (total 69)	2 vehicles* (total 68)	0.272#
2014	7 vehicles* (total 73)	4 vehicles* (total 73)	4 vehicles* (total 82)	13 vehicles* (total 86)	6 vehicles* (total 89)	11 vehicles* (total 93)	0.233#
Year	**July**	**August**	**September**	**October**	**November**	**December**	**Average (t CO_2e)**
2010	2 vehicles* (total 103)	36 vehicles* (total103)	7 vehicles* (total 103)	3 vehicles* (total 106)	3 vehicles* (total 106)	19 vehicles* (total 109)	0.200#
2011	n/a	8 vehicles* (total 118)	3 vehicles* (total 120)	4 vehicles* (total 119)	9 vehicles* (total 119)	19 vehicles* (total 118)	0.242#
2012	3 vehicles* (total 75)	n/a	4 vehicles* (total 74)	1 vehicle* (total 74)	2 vehicles* (total 71)	14 vehicles* (total 73)	0.266#
2013	2 vehicle* (total 68)	5 vehicles* (total 68)	4 vehicles (total 68)*	3 vehicles* (total 68)	4 vehicles* (total 70)	20 vehicles* (total 73)	0.272#
2014	19 vehicles* (total 120)	11 vehicles* (total 122)	8 vehicles* (total 122)	8 vehicles* (total 121)	12 vehicles* (total 129)	30 vehicles* (total 125)	0.233#

* Total number of vehicles available # Average t CO_2e used n/a = not applicable

Scope 1 (government vehicles) limitation of the data includes the missing months in which an average t CO_2e was used derived from the available fuel emissions (t CO_2e) for 5 years. It is assumed that, the average is representative of the data. Some vehicles had missing fuel, make and model information, where the average t CO_2e emission and petrol default emission factor was used respectively. It is assumed that this average is representative of the data. The officials with car allowance utilising their own private vehicles in rendering health services were excluded from the study, it is anticipated that these private vehicles are minimal in comparison to government fleet vehicles. Table 3.6 shows the number of vehicles where no make and model were available per month and in which the fuel emission factor was used as default for that specific year (see Table 3.4 for petrol emission factors).

Table 3.6 **Number of vehicles with no make & model (*) where a petrol emission factor was used (default) and average t CO_2e emissions (#) used for missing month derived from available fuel information for 5 years period**

Year	January	February	March	April	May	June
2010	1 vehicle* (total 101)	22.9# (t CO_2e)	22.9# (t CO_2e)	4 vehicles* (total 106)	4 vehicles* (total 105)	22.9# (t CO_2e)
2011	1 vehicle* (total 115)	1 vehicle* (total 115)	1 vehicle* (total 118)	1 vehicle* (total 118)	1 vehicle* (total 118)	1 vehicle* (total 116)
2012	4 vehicles* (total 118)	3 vehicles* (total 117)	3 vehicles* (total 116)	2 vehicles* (total 116)	5 vehicles* (total 111)	1 vehicle* (total 75)
2013	1 vehicle* (total 72)	1 vehicle* (total 70)	1 vehicle* (total 70)	n/a	n/a	n/a
Year	**July**	**August**	**September**	**October**	**November**	**December**
2010	2 vehicles* (total 103)	2 vehicles* (total103)	1 vehicle* (total 103)	2 vehicles* (total 106)	2 vehicles* (total 106)	2 vehicles* (total 109)
2011	22.9# (t CO_2e)	4 vehicles* (total 118)	5 vehicles* (total 120)	5 vehicles* (total 119)	5 vehicles* (total 119)	4 vehicles* (total 118)
2012	1 vehicle* (total 75)	22.9# (t CO_2e)	2 vehicles* (total 74)	3 vehicles* (total 74)	1 vehicle* (total 71)	2 vehicles* (total 73)
2013	n/a	n/a	n/a	n/a	n/a	n/a

* Number of vehicles with no make & model in which a petrol emission factor was used (default) for calculating fuel emission (t CO_2e)
# Missing data=Average t CO_2e emissions derived from available fuel emissions (t CO_2e) for a 5-year period [2010 -2014], was used.
n/a= not applicable

Table 3.7 shows manufacturer emission factors and default emission factors used in the calculation of manufacturer CO_2e emissions and online reference sources.

Table 3.7 **Emission factor (kg CO_2e/km) according to make and model of vehicle**

Vehicle make	Vehicle model	Emission factor (kg CO_2e/km)	References
Nissan	Hardbody NP300 2.4i D/C 4X2 (K13/K31)*	Default value	See Table 3.4
Chevrolet	Sonic 1.6 LS S/D A/T	0.161	http://www.chevrolet.co.za/cars/sonic-4-door/features-and-specs/models-
Nissan	Nissan 1400 LDV	0.234	http://www.icarinfo.net/?model=nissan-1400-bakkie-champ-2006
Mazda	323 130 HATCH	0.172	http://www.ultimatespecs.com/car-specs/Mazda/7519/Mazda-323-VI-
Chevrolet	Aveo 1.5LS	0.192	http://www.icarinfo.net/?model=chevrolet-aveo-1-5-ls-2008
Volkswagen	Caddy 1.6i P/Van	0,195	http://www.vw.co.za/en/models/caddy/trimlevel_overview.html
Volkswagen	Caddy 2.0TDi P/Van	0,147	http://www.vw.co.za/en/models/caddy/trimlevel_overview.html
Volkswagen	Citi Golf 1.4*	Default value	See Table 3.4
Volkswagen	Citi Golf Chicco 1.4	0.173	http://www.carsmind.com/specification.php?id=41620
Corolla	Corolla 140i	0.165	http://www.repairservicemanuals.com/Toyota/Corolla%20140i/2008/
Corsa	Corsa 1.4 Essentia	0.151	http://www.topmidi.com/opel-astra-14-essentia-19171/
Corsa	Corsa 1.4i	0.142	http://www.carfolio.com/specifications/models/car/?car=146520
Corsa	Corsa 1.4i Club	0.124	http://www.carsplusplus.com/specs2008/opel_corsa_ 14_club.php
Corsa	Corsa 140i Utility	0.173	http://www.carsplusplus.com/specs2006/opel_corsa_ utility_14.php
Corsa	Corsa 160i*	Default value	See Table 3.4
Corsa	Corsa Utility 1.8i LDV*	Default value	See Table 3.4
Ford	Fiesta 1.4i	116 g/km	https://www.car-emissions.com/cars/view/20221
Nissan	Hardbody 2.4i Scab LWB*	Default value	See Table 3.4
Isuzu	Isuzu KB 300*	Default value	See Table 3.4
Iveco	Iveco Daily 50C15V-15 3 ton P/Van*	Default value	See Table 3.4
Isuzu	KB280 DT LE LWB*	Default value	See Table 3.4
Nissan	Livina 1.6 Acenta (H84)	0.172	http://www.naamsa.co.za/ecelabels/
Mercedes	Mercedes Sprinter 311 CD1 16-Seater*	Default value	See Table 3.4
Nissan	Micra 1.4	0.154	http://www.carfolio.com/specifications/models/car/?car=199045
Nissan	Nissan Hardbody 2.4i Hi-Rider*	Default value	See Table 3.4
Nissan	Nissan Nv350 2.5p Wide Taxi 16-Seater Mini-bus	0.300	http://www.nissan.co.za/~/media/Files/Nissan/Asia%20Pacific/NSA/Specification/NV350_2014v3.pdf

Continued

Table 3.7 **Emission factor (kg CO_2e/km) according to make and model of vehicle** *(cont.)*

Vehicle make	**Vehicle model**	**Emission factor (kg CO_2e/km)**	**References**
Nissan	NPR 300*	Default value	See Table 3.4
Chevrolet	Optra 1.6 LS SD*	Default value	See Table 3.4
Volkswagen	Polo 1.4 Trendline	0.154.	http://www.repairservicemanuals.com/Volkswagen/Polo%201.4%20Trendline/2008/
Volkswagen	Polo 1.4 Trendline H/B	Default value	See Table 3.4
Volkswagen	Polo 1.6 Trendline	0.173	http://www.carsplusplus.com/specs2009/volkswagen_polo_16_trendline.php
Volkswagen	Polo Classic 1.4 Trendline*	Default value	See Table 3.4
Volkswagen	Polo Classic 1.4 Trendline S/D*	Default value	See Table 3.4
Volkswagen	Polo Vivo 1.4 Concept 5DR	0.147	http://www.vw.co.za/en/models/polo_vivo/trimlevel_overview.html
Volkswagen	Polo Vivo 1.4 Trendline	0.144	http://www.naamsa.co.za/ecelabels/
Volkswagen	Polo Vivo 1.6 Trendline	0.156	http://www.naamsa.co.za/ecelabels/
Nissan	Primastar 1.9 DCI 9-Seater*	Default value	See Table 3.4
Renault	Renault Kangoo 1.6 P/Van PH2	0.18	http://www.renault.com.au/vehicles/commercial/kangoo/kangoo/features-specifications
Toyota	Runx 160	0.184	http://www.carsplusplus.com/specs2006/toyota_runx_160i_rx.php
Mercedes	Sprinter 308CDI P/V*	Default value	See Table 3.4
Nissan	Tiida 1.6 Visia	0.164	http://www.autoevolution.com/cars/nissan-tiidaversa-2006.html#aeng_nissan-tiidaversa-2006-16-16v
Toyota	Toyota Avanza 1.3 SX P/V (43O)	0.172	http://www.toyota.co.za/Media/Default/brochures/avanza.pdf
Toyota	Yaris 1.3 T3	0.165	http://www.repairservicemanuals.com/Toyota/Yaris%201.3%20SD%20T3/2008/
Toyota	Yaris 1.3 T3 Spirit SD 06	0.165	http://www.repairservicemanuals.com/Toyota/Yaris%201.3%20SD%20T3/2008/
Toyota	Yaris T3 Spirit	0.165	http://www.repairservicemanuals.com/Toyota/Yaris%201.3%20SD%20T3/2008/

* DEFRA engine default emission factors used (see Table 3.4 for values)

3.6.2 Carbon footprint of electricity (Scope 2)

Electricity is supplied by Eskom via the local municipality to the health facilities. Eskom is a South African state owned Energy Utility. It supplies electricity to approximately 95% of the clients within the country (Eskom, 2016a). The carbon footprint of electricity is calculated by multiplying the kilowatts of electricity consumed by the facilities with the Eskom emission factor for sold and generated electricity for that specific financial year in question. In cases where Eskom emission factors were not available for both sold and generated electricity in the financial year, a default emission factor was used obtained by averaging the available emission factors as presented in Table 3.8.

In the case where the monthly electricity consumption of a specific facility was not available, such as the District Office, Nokuthela Ngwenya Clinic and Northmead Clinic, it was necessary to extrapolate the missing months by obtaining an average kilowatts derived from the available information for the specific facility (kilowatts) which was multiplied by Eskom emission factors (Table 8) for sold and generated for that specific financial year in question. Table 3.9 shows the available electricity kilowatts data per facility supplied by the finance unit which was used in the quantification of carbon footprint of electricity.

As explained in the data collection section (3.5.2), electricity consumption data was available at only three facilities, Nokuthela Ngwenya Clinic, Northmead Clinic and the District Office. Therefore, in order to compensate for the missing ten provincial clinics data (Table 3.2), it was necessary to extrapolate the data by averaging the available kilowatts from the two provincial facilities (Nokuthela Ngwenya Clinic and Northmead Clinic) and multiplying the average kilowatts to Eskom emission factors (Table 3.8) for sold and generated electricity for that specific financial year in question.

The limitation and assumption in Scope 2 (electricity carbon footprint) include the data limitation for ten 10 facilities, in which an average kilowatts derived from two provincial clinics was used to calculate their carbon footprints. It is assumed that the estimated average is representative, because the two provincial clinics covers both larger and smaller facilitates.

Table 3.8 **Eskom emission factors for specific financial years**

Eskom financial year	**Sold emission (Kg CO_2e/KWh)**	**Generated emission (Kg CO_2e/KWh)**	**Sources**
April 2009–March 2010	1.05*	1.00*	Averaged emission factor
April 2010–March 2011	1.05*	1.00*	Averaged emission factor
April 2011–March 2012	1.03	0.99	Eskom 2012
April 2012–March 2013	1.05*	0.98	Eskom 2013
April 2013–March 2014	1.07	1.03	Eskom 2014
April 2014–March 2015	1.05*	1.00*	Averaged emission factor

* Eskom emission factor unavailable, default emission factor obtained by averaging available emission factors

Table 3.9 **Available electricity data (kilowatts) for facilities**

Year	**January**	**February**	**March**	**April**	**May**	**June**
2010	—	—	—	—	—	—
2011	—	—	—	—	—	—
2012	** #**	** #**	** #**	#	#	#
2013	** # *	** # *	** # *	# *	# *	# *
2014	** # *	** # *	# *	# *	#	# *
Year	**July**	**August**	**September**	**October**	**November**	**December**
2010	—	—	—	—	—	—
2011	—	—	—	—	—	—
2012	#	#	#	#	#	** #
2013	# *	# *	*	*	#	** #
2014	#	—	#	#	# *	** # *

** District Office; # Nokuthela Ngwenya Clinic and * Northmead Clinic (denotes: available electricity kilowatts data per facility per month) — = No data available

3.6.3 Carbon emission from office paper (Scope 3)

As mentioned previously (see section 3.5.3), the Procurement Unit within the Ekurhuleni Health District Office is responsible for the procurement of office printing papers. The printing paper are centrally stored in the procurement area and dispatched to different health facilities. Therefore, in this study the dispatched office papers are regarded as being consumed or used by the respective health facilities upon dispatch. Sappi printing papers (A4 size) are mostly used in the District Office. Sappi has an international and global footprint of approximately 100 countries in three different continents (Sappi, 2015).

In order to obtain the emission factor of Sappi printing paper, literature and internet search were conducted looking into the company profiles and sustainability reports. The searches yield no concrete emission factor for South Africa. The only carbon emissions reported by the company in South Africa was for business travel for flights, car hire and hotel accommodations (Sappie, 2013:91). However, a 2013 Sappie Group Sustainability Report provided an emission factor of 0.77kg of CO_2e emissions per kilogram of pulp, based on material input (Scope 3) at the Somerset Mill Located in North America (Sappie, 2013:91). Upon an email communication, an emission factor of 1.81 t CO_2e/t (electricity excluded) and 1.94 t CO_2e (electricity included) were provided (R. van Hoeve, Sappi email communication, 10 May 2016). In contrast, further literature search on office paper emission factors in the South Africa context revealed a carbon footprint reported from a listed Johannesburg Stock Exchange (JSE) Company of the Bidvest Group (2014:18). In the report, an emission factor of 1.68 t CO_2e/t (electricity excluded) and 4.54 t CO_2e /t (electricity included) was used based on the production of Mondi Rotarim office paper. Mondi is also a JSE listed company. Mpact limited paper manufacturer is referred to as Mondi in this dissertation.

In conclusion, the office paper emission factors obtained through literature search and personal communication is presented in Table 3.10. The emission factors information are considered reliable because it was obtained from email communication (Sappi) and online published Bidvest group report (Mondi). In this study, the emission factor of Sappie is used to determine the overall carbon footprint of office paper because the District Office uses Sappie office paper.

Table 3.10 **Office paper emission factors according to sources**

Emission factor (t CO_2e/t	**Company**	**Source**
1.81 (electricity excl.) & 1.94 (electricity incl.)	Sappie	R. van Hoeve, email communication, 10 May 2016
1.68 (electricity excl.) & 4.54 (electricity incl.)	Mondi	Bidvest group (2014). *Bidvest group LTD 2014 carbon footprint report.* (Online) Available from: [http://www.bidvest.co.za/ar/bidvest_ar2014/pdf/greenhouse-carbon-footprint.pdf]. (Accessed on 28 October 2015).

Monthly office paper consumption from January 2010 to December 2014 was analysed in this study, however, office paper information was only available from April 2011 to December 2014. Therefore, in order to calculate the carbon footprint of office paper from January 2010 to December 2014, an average number of office paper boxes derived from the available data (April 2011 – December 2014) was used to calculate the CO_2e for the missing data (2010 and three months of 2011), as presented in Table 3.11. One ream office paper has a mass of 2481.2 grams as determined by an electronic scale. A box holds reams with a total resultant weight of 12.406kg per box.

Office paper weight and its carbon footprint were calculated by means of the following formula:

- Number of boxes X 12.406kg (total weight)
- Total weight (kg)/1000 (converting from kg to tons) X Emission factor.

Sixteen months of data on office printing paper (2010 and four months of 2011) was not available. An average number of office paper derived from the available information (April 2011 – December 2014) was used to estimate the carbon footprints for this missing period. This is considered a limitation of the Scope 3 office paper carbon footprints results. However, it is assumed that the results are representative. In some months facilities didn't require additional office papers from the procurement, therefore zero number of papers were dispatched.

Table 3.11 **Monthly office paper consumption from January 2010–December 2014**

Year	January	February	March	April	May	June
2010	126 boxes* (1563kg)	126 boxes* (1563kg)	126 boxes* (1563kg)	126 boxes* (1563kg)	126 boxes* (1563kg)	126 boxes* (1563kg)
2011	126 boxes* (1563kg)	126 boxes* (1563kg)	126 boxes* (1563kg)	60 boxes (744kg)	235 boxes (2915kg)	60 boxes (744kg)
2012	96 boxes (1191kg)	181 boxes (2245kg)	—	48 boxes (595kg)	147 boxes (1824kg)	48 boxes (595kg)
2013	47 boxes (583kg)	304 boxes (3771kg)	—	152 boxes (1886kg)	139 boxes (1724kg)	129 boxes (1600kg)
2014	60 boxes (744kg)	94 boxes (1166kg)	267 boxes (3312kg)	93 boxes (1154kg)	179 boxes (2221kg)	167 boxes (2072kg)
Year	**July**	**August**	**September**	**October**	**November**	**December**
2010	126 boxes* (1563kg)	126 boxes* (1563kg)	126 boxes* (1563kg)	126 boxes* (1563kg)	126 boxes* (1563kg)	126 boxes* (1563kg)
2011	192 boxes (2382kg)	170 boxes (2109kg)	—	118 boxes (1464kg)	146 boxes (1811kg)	48 boxes (595kg)
2012	66 boxes (819kg)	205 boxes (2543kg)	—	147 boxes (1762kg)	167 boxes (2072kg)	39 boxes (484kg)
2013	186 boxes (2308kg)	193 boxes (2394kg)	101 boxes (1253kg)	238 boxes (2953kg)	167 boxes (2072kg)	51 boxes (558kg)
2014	47boxes (583 kg)	322 boxes (3995kg)	109 boxes (1352kg)	162 boxes (2010kg)	210 boxes (2605kg)	65 boxes (806kg)

* Average number of boxes derived from the available information was used to compensate for missing data
— = Zero number of papers dispatched

3.6.4 Carbon emissions from Information and Communication Technology (ICT) (Scope 3)

ICT equipment are used daily for communication and administrative activities with the resultant energy consumption. A percentage of 90% of electricity production in South Africa is from coal (Winker, 2006:1). The ICT equipment included in this study consist of laptops, desktop printers, desktop monitors, cell phones and desktop central processing units (convertible & small factors).

At the time of writing the current dissertation, the current draft guideline to assess the carbon footprint of ICT equipment was not yet finalised by the Greenhouse Gas Protocol (GHGP, 2012b). Chapter 6 of the “Guide for assessing GHG emissions of hardware” specifies four methods for calculating greenhouse gas emissions for hardware, namely: Cradle-to-Gate by components characterisation; Cradle-to-Gate by hardware parameterisation; life-cycle stage ratio profiling; and environmentally extended input/output methods (GHGP, 2012a, 2).

In this current study, life cycle stage ratio profiling characterisation methodology was used to calculate the carbon emission associated with ICT equipment. This method makes provision for the quantification of carbon emissions based on the use stage of the ICT equipment in question. Most ICT equipment has a life-cycle of four years with the exception of cell phones, which has a two-year life expectancy (GHGP, 2012a:20).

However, in this study, a five-year life-cycle was used for ICT equipment. This was done to allow for the calculation of carbon footprint associated with ICT equipment for the reporting period (January 2010 to December 2014). Observations during the assessment revealed that some ICT equipment were older than five years. The Eskom emission factors used to calculate the CO_2e emissions associated with ICT from 2010 to 2014 is stipulated in Table 3.8.

3.6.4.1 Use stage emission for CPUs, monitors and printers

The following equations were used to calculate the power consumptions and the use stage carbon emission for CPUs, laptops, monitors and printers.

Power consumption (kWh) *= watts * use profile * Quantity * 0.001 (converting watts to kilowatts)*

Use stage GHG emission *= Power * Eskom Emission Grid Factor* Life Cycle* 0.001 (converting t* CO_2e*)*

3.6.4.2 Use stage emission for cell phones

In terms of use stage emission from Cell Phones, the first step was to calculate the watts from information obtained from the manufacturer such as milliampere hours (mAh) and volt (V), as shown in the below equation:

Power (Watts hours) *= Volts * (Milliampere/1000)*

The second step was to calculate the use stage GHG emissions, as shown in the equation below.

Use stage GHG emission *= Power * 0.001 (converting watts to kilowatts) *Use Profile * Eskom Emission Grid Factor * Quantity * Life Cycle * 0.001 (converting to t CO_2e)*

where:

Watts: Obtained from the manufacturer
Use profile: 20 days X 12 Month – 12 days (public holidays) X 8 hours =1824 hours per year: Cell phones =20 days X 12 months – 12 days (public holidays) X 0.33=75.24 hours per year
Eskom emission factor: Eskom sold emission factors for 2010-2014 in kg CO_2e/KWh
Quantity: The number of units available.
Life-cycle: Five years for total carbon emissions or one year for annual emissions.

The study limitations for the carbon footprint emissions of ICT equipment were: (1) In the use-stage, the statutory annual leave for employees was not taken into consideration for the GHG emission assessment; (2) The lowest power factor (watts) available was used in the case where the actual watts for the equipment were not obtainable from the manufacturer; (3) Standby carbon emissions were quantified for printers only; and (4) possibility of double accounting for ICT CO_2e emissions, since ICT equipment consumes electricity.

3.6.5 Carbon emissions from air conditioners (Scope 3)

During the physical inventory survey, data of only five facilities were obtainable, which were four provincial clinics and one district office. Therefore, in order to quantify the carbon footprints of the air conditioners in the district and provincial clinics, it was necessary to extrapolate for the eight provincial clinics. This was done by averaging the available number of air conditioners in the four provincial clinics (excluding the District Office because it is an administration office) and using this average number of air conditioners for the calculation of the carbon footprints of air conditioners. It was assumed that the types of the missing numbers of air conditioner refrigerants are likely to be HCF-23 types. Carbon emissions associated with air conditioners can be quantified by using three methods (GHGP, 2012c), namely:

- Sale based approach for manufacture and users;
- Life cycle stage approach for users; and

- Basic screening approach.

The use of these methods depends on the availability of data, for instance the sale base approach requires emission information from equipment, manufacturing, installation, servicing, etc. The screening approach requires less information and mainly based on default values and hence less accurate in comparison with other methods (GHGP 2005:3).

Due to the availability of information, it was only viable to use the screening method in this study. Where default emission factor values were required by this method, the lowest number was used resulting in estimates of emission. The quantity of refrigerant sent for destruction and time since last recharge (years) were not available from the manufacturer (via internet search) and no data was available from the District Office. This information was required for the calculation by GHG Protocol methodology. In order to be consistent and remain true to the data at hand, zero was used as a default during the quantification of emission factors. Furthermore data on the number of air conditioners and refrigerant was obtained and captured in the Microsoft Excel spread sheet provided by GHG Protocol (GHGP, 2012c).

The study limitation in this section (air conditioners) includes: The unavailability of data of eight facilities in which an average number of air conditioners was obtained by using the available information. Therefore, in this study it is assumed that the average used is a true representation, because it consists of different sizes of facilities. The methodology required certain information which could not be obtained (recharge years & number of equipment sent for destruction) where zero was used. Where the methodology required a default emission factor, the lowest available factor was used that may underestimate the results.

The steps below were used to calculate the CO_2e emissions associated with air conditioners, as per GHG Protocol Worksheet 3: screening methods for Hydrofluorocarbons (HFC) and Perfluorocarbon (PFC) emissions from refrigeration/air conditioner equipment (GHGP, 2012c).

Step 1: Determine the annual net HFC & PFC emissions from assembly/installation:

Number of units * Global warming positional (GWP) of refrigerant# * original refrigerant charge per unit# * assembly/installation emission factor# * conversion factor (tones/kilograms)

Step 2: Determine net gross HFC & PFC emissions from operation of refrigerants/ air conditioners:

Number of units * GWP of refrigerant# * refrigerant charge# * annual leakage rate# * conversion factor (tonnes of CO2 equivalent/year)

Step 3: Determine annual net HFC & PFC emissions from disposal of refrigerants/air conditioners:

((Number of units * original refrigerant charged#) * (1- (annual leakage# * time since last charged)) * (1-recycling efficiency) – 1) * GWP of refrigerant# * Conversion factor (tonnes/kg)

Step 4: Determine annual net HFC & PFC emissions:

Result in Step1 + Result in Step 2 + Result in Step 3

#Default values obtained from Tables in the methodology.

3.7 QUALITATIVE STUDY DESIGN

Qualitative study design uses a description approach of persons, events and relationships, and is presented in categories or general statements regarding the complex nature of persons, groups or events (Mark, 1996:211). Additionally, Christensen (1994:45) explains that descriptive research clarifies certain phenomenon, identify and describe the different variables within this phenomenon, and normally does not attempt to show cause and effect relationships. The phenomenon under investigation is examined in detail to seek an in depth understanding and meaning for the development of theory (Daly, 2003:193). Therefore, the qualitative study design was used in order to determine the knowledge and perception phenomenon of climate change among managers and operational employees in Ekurhuleni Health District.

There are basically five types of qualitative research approaches, namely case study, ethnographic study, phenomenological study, grounded theory study and content analysis. Although these approaches are different from each other, all these approaches focus on a real world phenomenon and tend to study the complexity of this phenomenon (Leedy & Ormrod, 2012:139).

In this study, content analysis was used. Leedy and Ormrod (2015:275) define content analysis as “detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes or biases”. Such analyses are performed on human communication including transcription of conversations. In content analysis, the text is examined in terms of the words and terms used, which are normally quantified by counting the frequency of the number of words or terms used (Miller & Brewer: 2003:44). In addition, Jupp (2006:41) defines content analysis as a measure to show a meaning or idea in a document by looking at the frequency of times the item appears or are used in the context.

3.7.1 Sampling

Sampling involved the selection of research participants from a population when it is not feasible to include the whole population in a study due to time or financial implications (Jupp, 2006:271). The selected individuals from the population should be representative in terms of characteristics so that the findings can be generalised (Tucker, 2005:386; Trobia, 2008:784). There are two strategies in sampling in a qualitative study, namely: (1) empirical strategy also called statistical strategy and (2) theoretical strategy also called purposive strategy or non-probability strategy (Schwandt, 2007:269).

Morse (2004:885) defined purposively strategy as "the deliberate seeking out of participants with particular characteristics, according to the need of developing analysis or emerging theories". Patton (2002) adds further clarity explaining that in purposive sampling participants selected should be knowledgeable and familiar with phenomenon under investigation. Therefore, in this study purposive sampling was used to select participants to determine knowledge and perception of climate change among managers and operational employees.

In order to obtain a balanced knowledge and perception of climate change in Ekurhuleni Health District office and Provincial Clinics employees, the participants were purposively selected from five facilities, namely District Office, Northmead Clinic, Managula Clinic, Kwa-Temba and Nokutela Ngwenya Clinic. A total of 33 participants were selected of which 10 were managers and 23 were operational employees from the above-mentioned facilities. However, due to a lower response rate (two participants) in the top management level, it was necessary to combine top management and middle management as the management category.

3.7.2 Data collection

Face-to-face interviews were used in this study as a tool for data collection. Dialsingh (2008:260) explained that face-to-face interviews are the most preferred tool used for data collection in surveys and consist of three types, namely the structured interview, the semi-structured interview and the unstructured interview. Smith and Bowers-Brown (2010:118) describe semi-structured interview as a process of interviewing using a set of questions, where the researcher can change the wording or sequence of the questions, while the unstructured interview is more of discussion type with rough idea of what to ask during the interview. On the other hand, the structured interview uses pre-set questions where all the participants are asked similar question in a similar fashion with little follow-up questions (Freeman, 2005:211).

The structured interview was used in this study, with an open-ended questionnaire as an interview guide or schedule. An interview schedule is a document with a list of questions which are read to the research participants during the interview (O'Leary & Miller, 2003:253). Additionally, Barbour (2008:115) explained that an interview schedule consists of open-ended questions to allow the respondent to express their views and usually start off with less complicated questions. Interview schedule tool was used in the study as provided in Appendix D and basically consists of a section A and a section B, with two and nine questions respectively.

In addition to the interview schedule, a tape recording device was used. The aim of using the tape recorder was to assist the researcher in capturing a variety of information and opinions regarding the perception of climate change and to review the information in more detail. The use of a digital device in data collection is not a new practice (Crichton, 2010:951).

Prior to data collection, research ethics clearance certificate was obtained from Ekurhuleni Health District Research Committee (project number: 19-09-2013-01) and University of South Africa (UNISA) Ethics Committee (reference number 2013/CAES/030). Furthermore, permission to access data was also approved from the Chief Director of the District office; see Appendix A, B and C. It is crucial to obtain ethical approval from relevant departments before the commencement of research. Research participants were asked to sign a consent form before the commencement of the interview (Appendix E).

Interviews were conducted over a period of a week from the 8th to the 12th of December 2014 at the place of employment of the research participants that included the District Office and the provincial health facilities. An email communication was sent to the Deputy Director one week prior to the interviews as a reminder of the interview, together with a copy of the interview schedule. Before the interview commenced, each research participant was issued with a consent form. The aspects of the consent form, such as the purpose, confidentiality, withdrawal, benefits, etc. were explained and an opportunity was provided to clarify aspects of the study (consent form in Appendix E). The conditions of participation in the study were voluntary and the researcher explained the purpose and benefits and any discomfort that needed to be addressed (Research Ethics, 2006:45). Furthermore, Kellet (2005:32) elucidated that consent from the participants is required before any research can commence as an understanding of the process of the research.

3.7.3 Analysis of data

As stated earlier, content analysis was used in this study. Lavrakas (2008:141) defined content analysis as “a research method that is applied to the verbatim responses given to open-ended questions in order to code those answers into a meaningful set of categories that lend themselves to further quantitative analysis”. Furthermore, Brewer (2003:45) explains that content analysis allows for information to be organised systematically in such a way that allows for words to be counted and for theme analysis to be conducted. Therefore, in this study it was appropriate to use content analysis, because it allows for the compiling a frequency table after counting keyword or ideas and the generation of themes.

Verbal interview responses were transcribed into a Microsoft Word document. Verbal transcription is writing down the exact words spoken by the research participants (Smith & Davies, 2010:148). Poland (2008:885) explains that transcriptions involve the transformation of the recorded conversation into written text for the purpose of analysis. During the transcription process, the interview responses were coded. Smith and Davies (2010:152) articulated that labelling data using codes is the beginning of the data analysis. In this study, the responses of the managers were coded as A1 to A10, while the responses of the operational employees were coded as B1-B23. The transcript was read several times on different days in order to identify and verify emerging perceptions and ideas from the interview transcripts. Barbour (2008:192-193) indicated that transcription involves the transformation of interview conversation into textual transformation, which allows the researcher to return to the data later on for further analysis.

Knowledge and perceptions were coded and grouped according to different keywords and descriptions. Coding is used in qualitative research analyse data by sorting the collected information in such a way that the required information can be separated from the collected data and produce similar based information (Maxwell & Chmiel, 2014:24). Coding data into categories is a way of reducing information into manageable units for theme analysis (Kellett, 2005:100). The keywords descriptions were quantified into a frequency table to identify re-occurring keywords and descriptions, which was used to develop emerging themes.

Chapter 4
RESULTS AND DISCUSSION OF CARBON FOOTPRINTS

This chapter presents the results and discusses the different carbon variable emission sources and their related carbon dioxide equivalent (CO_2e) emissions associated with Ekurhuleni Health District office and provincial clinics employees. In order to accomplish the first research objective of the study, which is to estimate the carbon dioxide equivalent (CO_2e) emissions associated with Ekurhuleni Health District and provincial clinics employees, different carbon variable sources and their emissions are presented and discussed based on per scope structure (1, 2 & 3) in accordance with the Greenhouse Gas Protocol (GHGP) procedure. Firstly, Scope 1 carbon emissions associated with government fleet vehicles are examined i.e. annual and monthly CO_2e emissions of vehicles, activities CO_2e emissions etc. Followed by Scope 2 emissions from electricity is discussed. Finally, Scope 3 carbon emissions from office paper, Information and Communication Technology (ICT) and emissions associated with air conditioners are presented. The figures and tables presented in this chapter were rounded to a decimal place.

4.1 SCOPE 1: CARBON EMISSIONS OF GOVERNMENT FLEET VEHICLES

4.1.1 Annual carbon emissions of vehicles

Government fleet vehicles contributed 4% of the total carbon footprint of Ekurhuleni Health District and provincial clinics for the five-year period, 2010 to 2014. It is essential to analyse the CO_2e emissions of the fleet vehicles and understand its contribution to annual emissions. The total fuel used, both petrol and diesel, and the derived t CO_2e emissions are examined.

Table 4.1 **Fuel consumption (both petrol and diesel) and CO_2e emissions for different years**

Years	Fuel consumed (Litres)	t CO2e (DEFRA)
2010	96410	252
2011	129296	328
2012	111673	277
2013	86899	222
2014	107138	283
Total	531416	1362

Table 4.1 presents the vehicle CO_2e emissions and fuel used in years from 2010 to 2014. In addition, it shows a direct link between fuel consumption and CO_2e emissions, where a larger amount of fuel usage results in larger CO_2e emissions released into the atmosphere. Both the highest CO_2e emissions produced and fuel consumption occurred in 2011 and the least in 2013.

The number of vehicles available to render health services vary per month, therefore the average number of vehicles used per year is shown in Figure 4.1. The average number of vehicles that render health services were higher in 2011 (116 vehicles) than those in the others years. This may be attributed to the higher t CO_2e emissions in 2011. Furthermore, in 2013 there were less vehicles (69) thus resulting in the least CO_2e emissions. These results correspond with that shown in Table 4.1

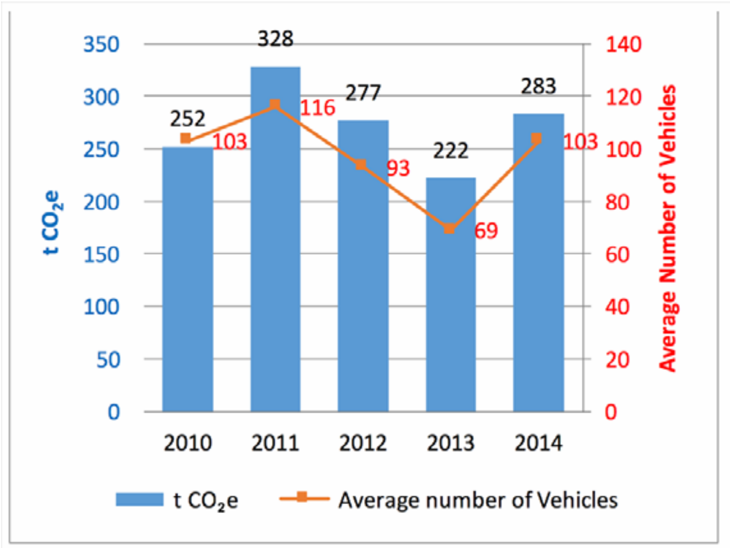


Figure 4.1 **Average number of vehicles per year in relation to total t CO_2e emissions**

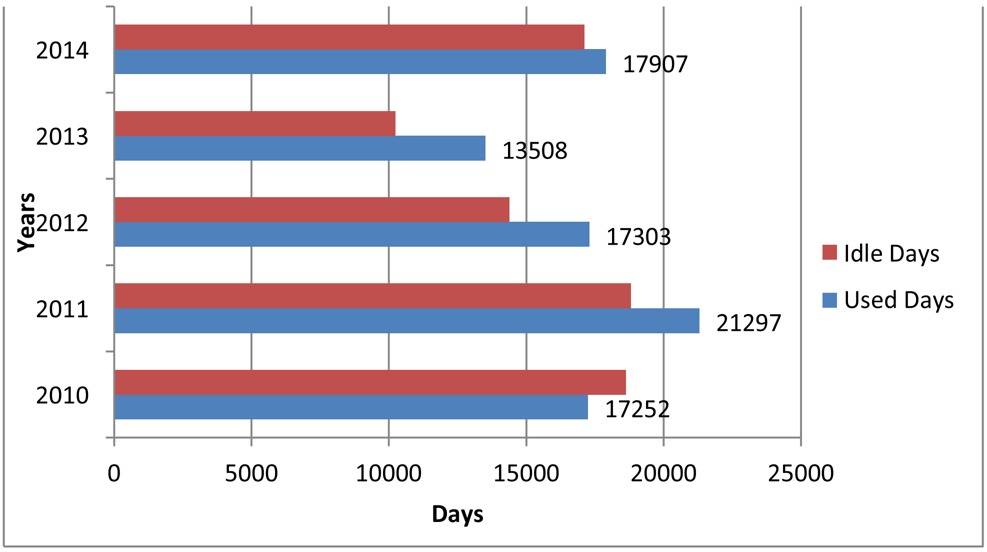


Figure 4.2 **Number of vehicles on used and idle days**

When looking at the vehicles activity levels (vehicles used days and vehicles idle days) between 2010 to 2014 (Figure 4.2), the highest used vehicle days occurred in 2011 (21297 vehicle days). This further supports the reasons for the higher CO_2e emissions produced in 2011. In contrast, the least used vehicle days occurred in 2013 (13508 days). This could be attributed to the decrease in the average number of vehicles available in 2013, due to the District Office failing to make their payment to the service provider, which resulted in vehicles being recalled.

4.1.2 Monthly carbon emissions from vehicles

After an investigation pertaining to monthly fuel CO_2e emissions for the period January 2010 to December 2014, a sudden peak in CO_2e emissions was found, occurring in March 2011 and July 2012 (Figure 4.3). Logistically, the sharp fuel CO_2e emissions peak in March 2011 and July 2012 cannot be account for; therefore it is very likely that this peak might be attributed to either (a) inherent data capturing error on fuel used by the vehicles at the source (transport department) and (b) possible recording error.

Nevertheless, the possible fuel CO_2e emission trend for December for all the years (2010 -2014) display decreases in the CO_2e emissions (Figure 4.3). This may be attributed to employees going on leave during the December holidays. A gradual increase in the CO_2e emissions is noted from January to March in most of the years (2011-2014), which may be ascribed to employees coming back from leave resulting in increased activity.

The highest monthly CO_2e emissions occurred in March and May 2012 (apart from the above mentioned data source errors in March 2011 and July 2012) emitting 32 and 31 t CO_2e respectively (Figure 4.3). The lowest CO_2e emissions occurred in December 2012 (14 t CO_2e) and December 2013 (14 t CO_2e). An average CO_2e emission of 23 t CO_2e (obtained by averaging the available data from all the months) was used in months were no source data was available (February 2010, March 2010, June 2010, July 2011 and August 2012).

The total number of government fleet vehicles, both used and idle vehicles, available for rendering health services within Ekurhuleni Health District from Janaruy 2010 to December 2014, is shown in Figure 4.3. The average of 97 vehicles were available that was obtained from averaging vehicles in all months. This average was used for the months where no data was available, for example in February 2010, March 2010, June 2010, July 2011 and August 2012. There was an increase in the number of vehicles from June 2010 to October 2011. Thereafter the number of vehicles begin to decrease slightly.

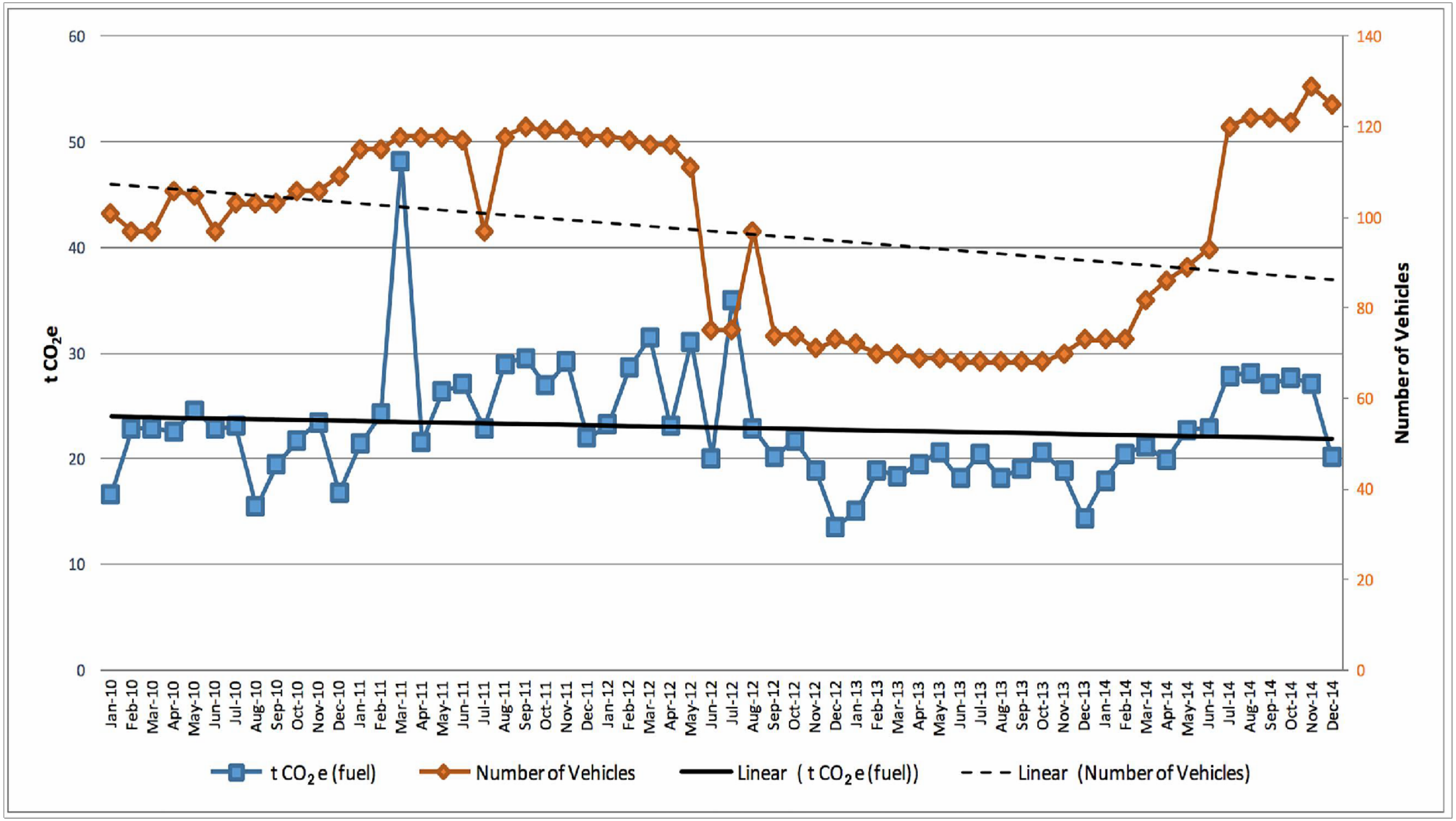


Figure 4.3 **Monthly fuel CO_2e emission (DEFRA) and total number of vehicles (used and idle) from January 2010 to December 2014**

A substantive reduction in the number of vehicles occurred in June 2012, where 111 vehicles (May 2012) were reduced to only 75 vehicles (June 2012). This sudden decrease in the number of vehicles may be attributed to the fleet service provider re-calling their vehicles due to non-payment by the District Office. The sudden decrease in the number of vehicles had a direct influence on the CO_2e emissions, reducing from 31 t CO_2e (May 2012) to 20 t CO_2e (June 2012) showing a difference of 11 t CO_2e in emissions.

A further seven vehicles were re-called from June 2012 to June 2013 resulting in only 68 vehicles available for health services. The number of vehicles begins to increase slightly from November 2013 to June 2014. Thereafter, there was an expeditious increase in the number of vehicles from 93 vehicles in June 2014 to 120 vehicles in July 2014, reaching its peak of 129 vehicles in November 2014. This sudden increase in the number of vehicles had shown an increase of 5 t CO_2e per month emissions for June 2014 to July 2014. The increase in the number of vehicles may be associated with payment made to the service provider and securing a new contract by with the service provider. Figure 4.3 show a sudden decrease in the number of vehicles (June 2012) resulting in a slight decrease in the CO_2e emissions, may be attributed to the service provider re-calling the vehicles (Figure 4.3).

4.1.3 Activities: CO_2e emissions on days for used and idle vehicles

Figure 4.4 shows the vehicle activities on used and idle days and the associated CO_2e emissions. The maximum vehicle usage occurred in September 2011 (2129 vehicles used days) followed by October 2014 (2044 vehicles used days), which emitted 30 and 28 t CO_2e emissions in total for each year respectively. However, the highest CO_2e emissions occurred in March 2012 (32 t CO_2e) with vehicle usage days of 2018 and May 2012 (31 t CO_2e) with 1414.

The t CO_2e emissions in March 2011 and July 2012 are not considered in this study due to data source errors as discussed in section 4.1.2. The downward trend for used days, idle days and CO_2e emissions may be attributed to the service provider re-calling the vehicles.

4.1.4 Fuel, engine size and vehicle manufacturer emission

Figure 4.5 concur with the possibility of data capturing error in fuel CO_2e emissions in March 2011 and July 2012. A comparison between CO_2e emissions for fuel and engine size shows that the engine size CO_2e emissions (derived from multiplying the kilometres travelled by the vehicle's engine size emission factor) show no sudden peak in March 2011 and July 2012.

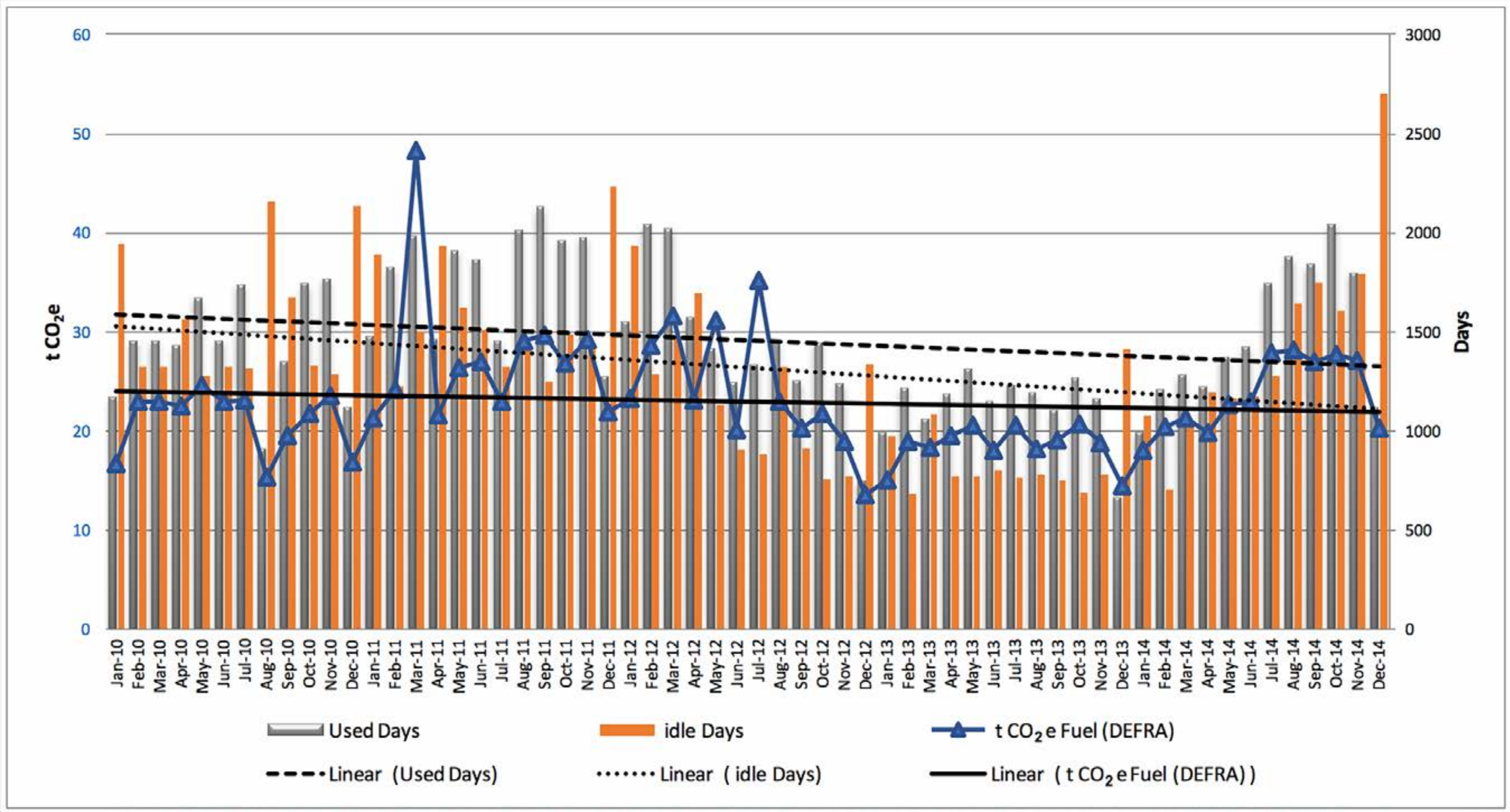


Figure 4.4 **Vehicles activity and CO_2e emissions from January 2011 to December 2014**

The sudden increase in the fuel CO_2e on these months (March 2011 & July 2012) should have also shown a similar visual peak in engine CO_2e emissions, because fuel consumption is linked to the kilometre travelled by vehicles, as presented in Figure 4.5.

Department of Environmental Forest and Rural Affairs (DEFRA) provides methodology that includes different emission factors to be used when calculating the carbon footprint of passenger vehicles owned or controlled by the organisation. DEFRA provide emission factors for different fuels, vehicle engine sizes and vehicles by market segment. The manufacturers of vehicles also provide vehicle specific emission factors. In calculating the CO_2e of a vehicle, only 58% of the specific vehicle emission factors of manufacturers were obtainable in the public domain, therefore, DEFRA engine size emission factors were applied for 32% of the vehicles as default values and 10% of the vehicles had missing/no model data in which average manufacturer CO_2e emissions were used from available information as presented in Table 4.2 (next page).

CO_2e emissions of vehicles derived from available fuel usage, engine size and manufacturer emission factors are presented in Figure 4.6. There is a little difference between CO_2e emissions derived from DEFRA engine size versus total manufacturer emissions. This may be attributed to an engine size default emission factor being used to compensate for missing public domain emission factor data for specific individual vehicle manufacturers. There is a considerable difference in DEFRA fuel CO_2e emissions in comparison with engine size and CO_2e emissions from the manufacturer (Figure 4.6). This may be attributed to fuel emission factors being higher than engine size emission factors, for example in 2014 DEFRA reported emission factor for petrol being 2.299kg CO_2e, while the engine size emission factor for small vehicles is 0.147kg CO_2e, for medium 0.177kg CO_2e and for large 0.230kg CO_2e (see Table 3.4). The fuel CO_2e emissions in March 2011 and July 2012 are not considered in this study due to data source errors, as explained in section 4.1.2.

4.1.5 Emissions from petrol and diesel vehicles

In this section fuel CO_2e emissions are further analysed by comparing petrol and diesel emissions. When rendering health services to the community for instance health promotion activities such as malaria cases investigation, health professionals require different types of vehicles to access remote areas for example informal settlements. The diversity of vehicles in Ekurhuleni Health District cater for such different needs and the fleet includes: one-ton utility vehicles, light passenger vehicles and mini buses, resulting in both diesel and petrol engines being part of vehicle the fleet.

Table 4.2 **Percentage emission of manufacturers and default emission factors used and percentage of missing data**

Vehicle make	Model of vehicle	% Vehicles	% Default used	% Manufacturer emission used	% Missing/no model data
	Missing data**	8.62%			8.62%
Nissan	Hardbody NP300 2.4i D/C 4X2 (K13/K31)*	0.28%	0.28%		
Chevrolet	Sonic 1.6 LS S/D A/T	0.03%		0.03%	
Nissan	Nissan 1400 LDV	0.31%		0.31%	
Mazda	323 130 hatch	0.50%		0.50%	
Chevrolet	Aveo 1.5LS	0.84%		0.84%	
Volkswagen	Caddy 1.6i P/Van	2.20%		2.20%	
Volkswagen	Caddy 2.0TDi P/Van	0.10%		0.10%	
Volkswagen	Citi Golf 1.4*	4.91%	4.91%		
Volkswagen	Citi Golf Chicco 1.4	1.70%		1.70%	
Toyota	Corolla 140i	2.51%		2.51%	
Corsa	Corsa 1.4 ESSENTIA	1.67%		1.67%	
Corsa	Corsa 1.4i	5.18%		5.18%	
Corsa	Corsa 1.4i Club	0.84%		0.84%	
Corsa	Corsa 140i Utility	0.41%		0.41%	
Corsa	Corsa 160i*	0.41%	0.41%		
Corsa	Corsa Utility 1.8i LDV*	0.43%	0.43%		
Ford	Fiesta 1.4i	3.17%		3.17%	
Nissan	Hardbody 2.4i Scab LWB*	1.89%	1.89%		
Isuzu	KB 300*	0.71%	0.71%		
Iveco	Iveco Daily 50C15V-15 3 ton P/Van*	3.87%	3.87%		
Isuzu	KB280 DT LE LWB*	0.22%	0.22%		
Nissan	Livina 1.6 Acenta (H84)	2.34%		2.34%	
Mercedes	Sprinter 311 CD1 16-Seater*	0.07%	0.07%		

Continued

Table 4.2 **Percentage emission of manufacturers and default emission factors used and percentage of missing data** ***(cont.)***

Vehicle make	Model of vehicle	% Vehicles	% Default used	% Manufacturer emission used	% Missing/no model data
Nissan	Micra 1.4	3.18%		3.18%	
Nissan	Hardbody 2.4i Hi-Rider*	7.78%	7.78%		
Nissan	NV350 2.5P Wide taxi 16-Seater Mini Bus	0.07%		0.07%	
	No model**	1.19%			1.19%
Nissan	NPR 300*	1.89%	1.89%		
Chevrolet	Optra 1.6 LS SD*	1.26%	1.26%		
Volkswagen	Polo 1.4 Trendline	0.52%		0.52%	
Volkswagen	Polo 1.4 Trendline H/B	9.67%		9.67%	
Volkswagen	Polo 1.6 Trendline	5.41%		5.41%	
Volkswagen	Polo Classic 1.4 Trendline*	1.27%	1.27%		
Volkswagen	Polo Classic 1.4 Trendline S/D*	5.92%	5.92%		
Volkswagen	Polo Vivo 1.4 Concept 5dr	7.16%		7.16%	
Volkswagen	Polo Vivo 1.4 Trendline	1.24%		1.24%	
Volkswagen	Polo Vivo 1.6 Trendline	0.45%		0.45%	
Nissan	Primastar 1.9 DCI 9-Seater*	0.86%	0.86%		
Renault	Kangoo 1.6 P/Van Ph2	0.15%		0.15%	
Toyota	Runx 160	1.70%		1.70%	
Mercedes	Sprinter 308cdi P/Van*	0.14%	0.14%		
Nissan	Tiida 1.6 Visia	2.55%		2.55%	
Toyota	Avanza 1.3 SX P/V (43o)	0.10%		0.10%	
Toyota	Yaris 1.3 T3	0.84%		0.84%	
Toyota	Yaris 1.3 T3 Spirit SD 06	2.56%		2.56%	
Toyota	Yaris T3 Spirit	0.83%		0.83%	
	Grand Total	**100.00%**	**32.00%**	**58.00%**	**10.00%**

* DEFRA engine default emission factors used **Missing data/no model= average manufacturer CO_2e emissions from available information

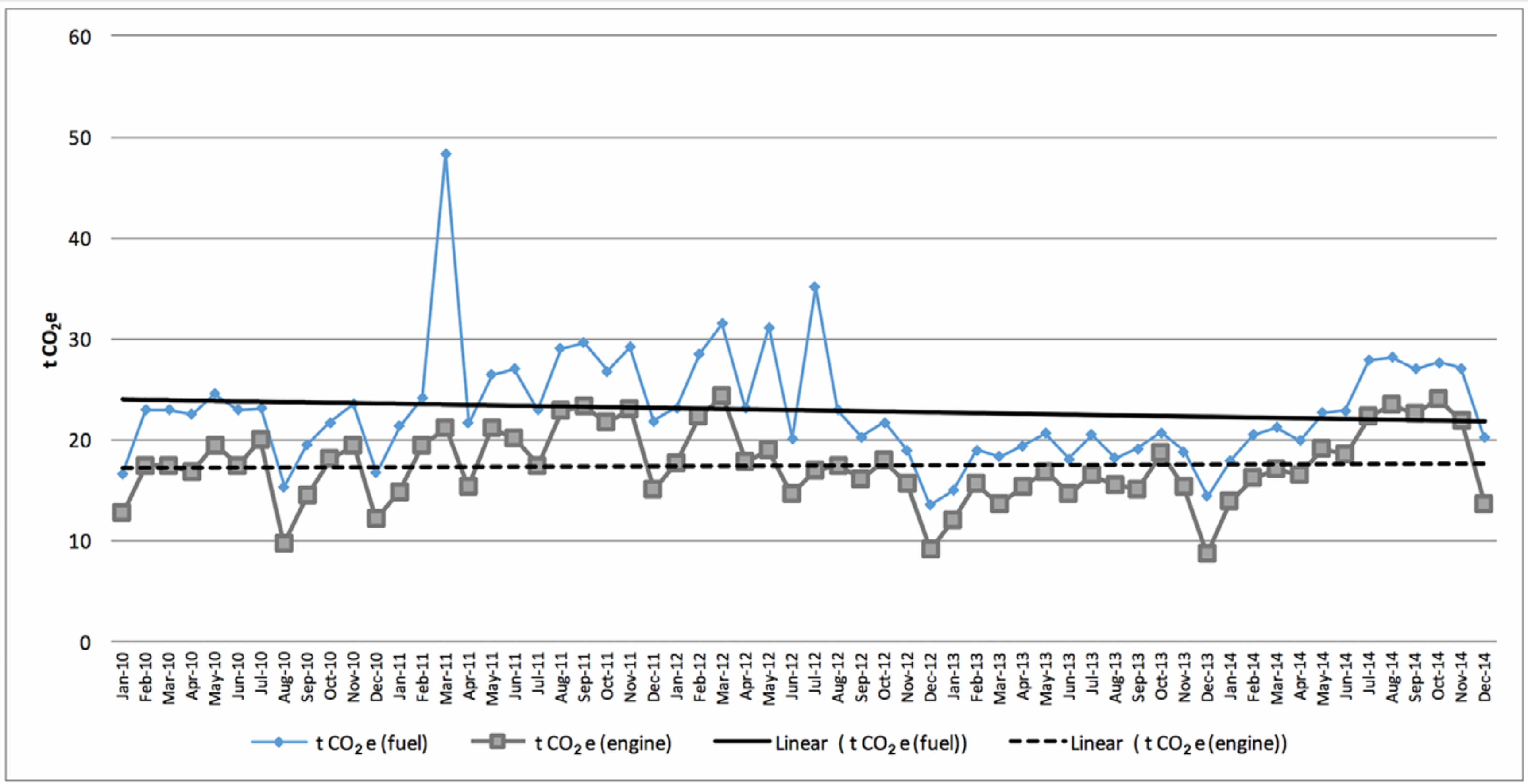


Figure 4.5 **Comparison of CO_2e emission of fuel and engine size from January 2010 to December 2014**

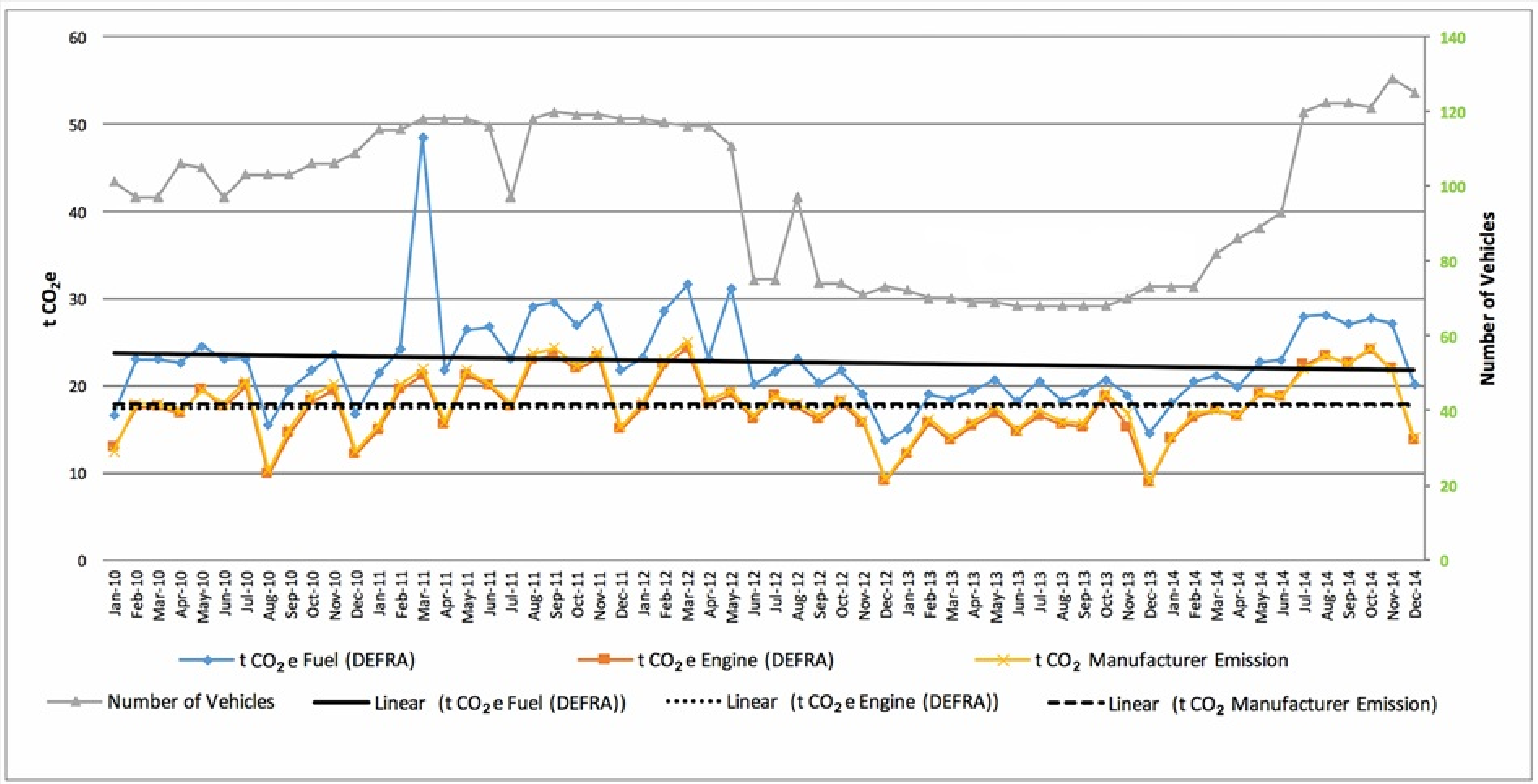


Figure 4.6 **Comparison of t CO_2e for fuel (DEFRA), engine size (DEFRA) and manufacturer from January 2011 to December 2014**

The quantification of CO_2e emissions associated with petrol and diesel is based on different DEFRA emission factors to be multiplied by the quantity of petrol or diesel. Figure 4.7 presents diesel CO_2e emissions and number of diesel vehicle from January 2010 to December 2014. The highest CO_2e emissions occurred in May 2012, emitting 7 t CO_2e into the atmosphere and the least occurred in August 2010, emitting 1 t CO_2e emission, with diesel vehicle number of ten and six respectively. Regarding missing month data (February 2010, March 2010, June 2010, July 2011 and August 2012), monthly average diesel CO_2e emissions (4 t CO_2e) of nine diesel vehicles were used.

The highest petrol CO_2e emissions occurred in March 2012 emitting 25 t CO_2e and the lowest occurred in December 2012 emitting 10 t CO_2e with the number of petrol vehicles being 106 and 65 respectively (Figure 4.8). An average monthly petrol emission of 19 t CO_2e and 88 petrol vehicle number was used for the missing month data. The unusual CO_2e emission peak in March 2011 was excluded in the study due to data source error, as explained in section 4.1.2.

4.1.6 Comparison of CO_2 emissions from petrol and diesel vehicles

In the current comparison, the diesel CO_2e emission is much lower than the petrol emissions. It is due to the lower number of diesel vehicles (Figure 4.9) compared to the petrol vehicles and its associated resultant emissions.

The petrol CO_2e emission trend lines show a downward trend, which could be because of the re-call of vehicles by the service provider due to non-payment by the District Office. However, the diesel CO_2e emission trends show a slight upward trend, which may be attributed to the diesel vehicle being used more often when the service provider re-called mostly petrol vehicles.

4.1.7 Comparison of WRI GHG Protocol and DEFRA methodology for calculating CO_2e emissions for petrol and diesel vehicles.

Current methodologies available to quantify carbon footprints of vehicles include Department of Environmental Forest and Rural Affairs (DEFRA), World Resource Institute (WRI) GHG Protocol Tool for Mobile Combustion (version 2.6) and International Standard Organisation (ISO) 14067: 2013 Greenhouse Gas Emissions. In this study, reference is made to DEFRA and GHG Protocol methodologies only.

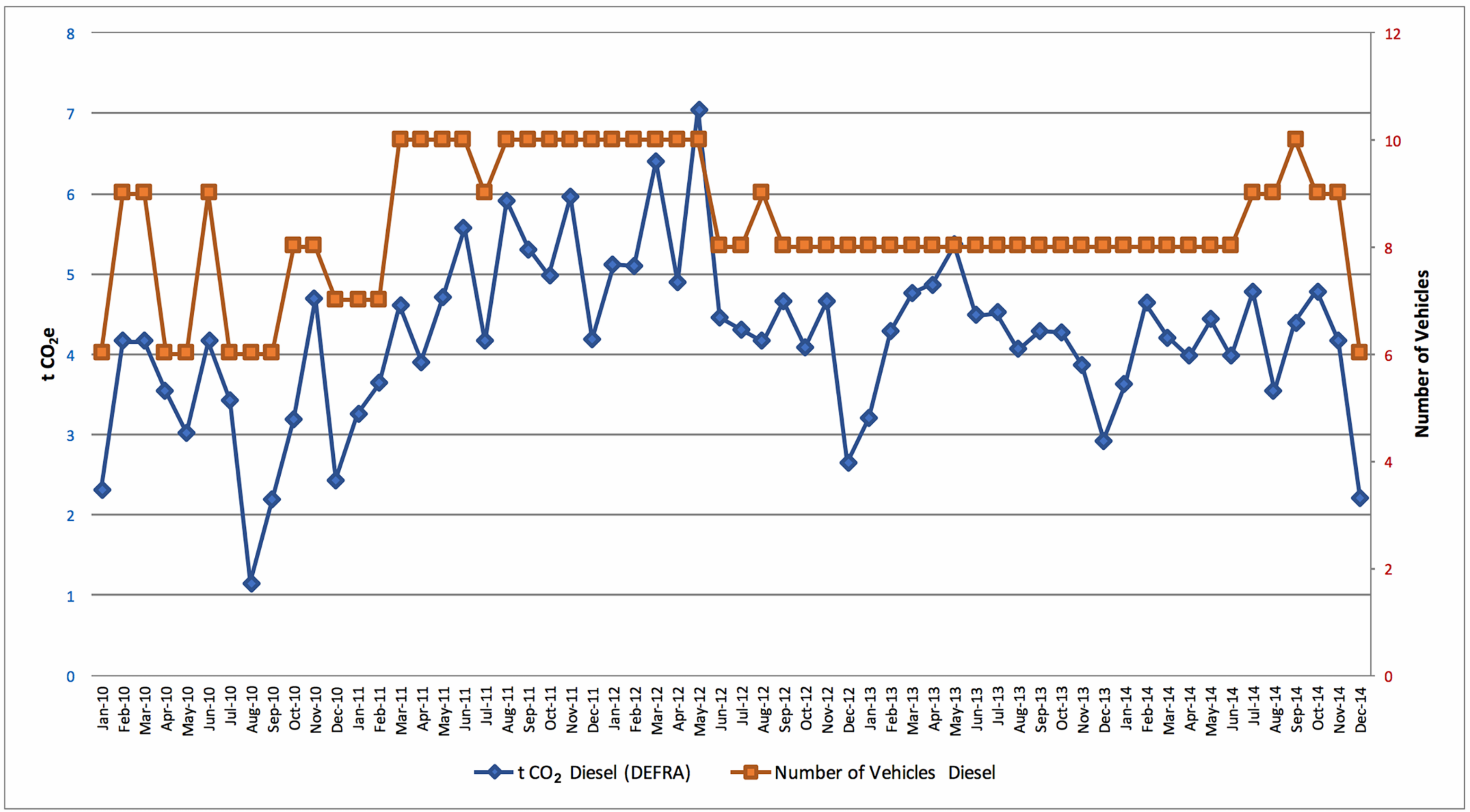


Figure 4.7 **Diesel CO_2e emissions (DEFRA) and number of available vehicles**

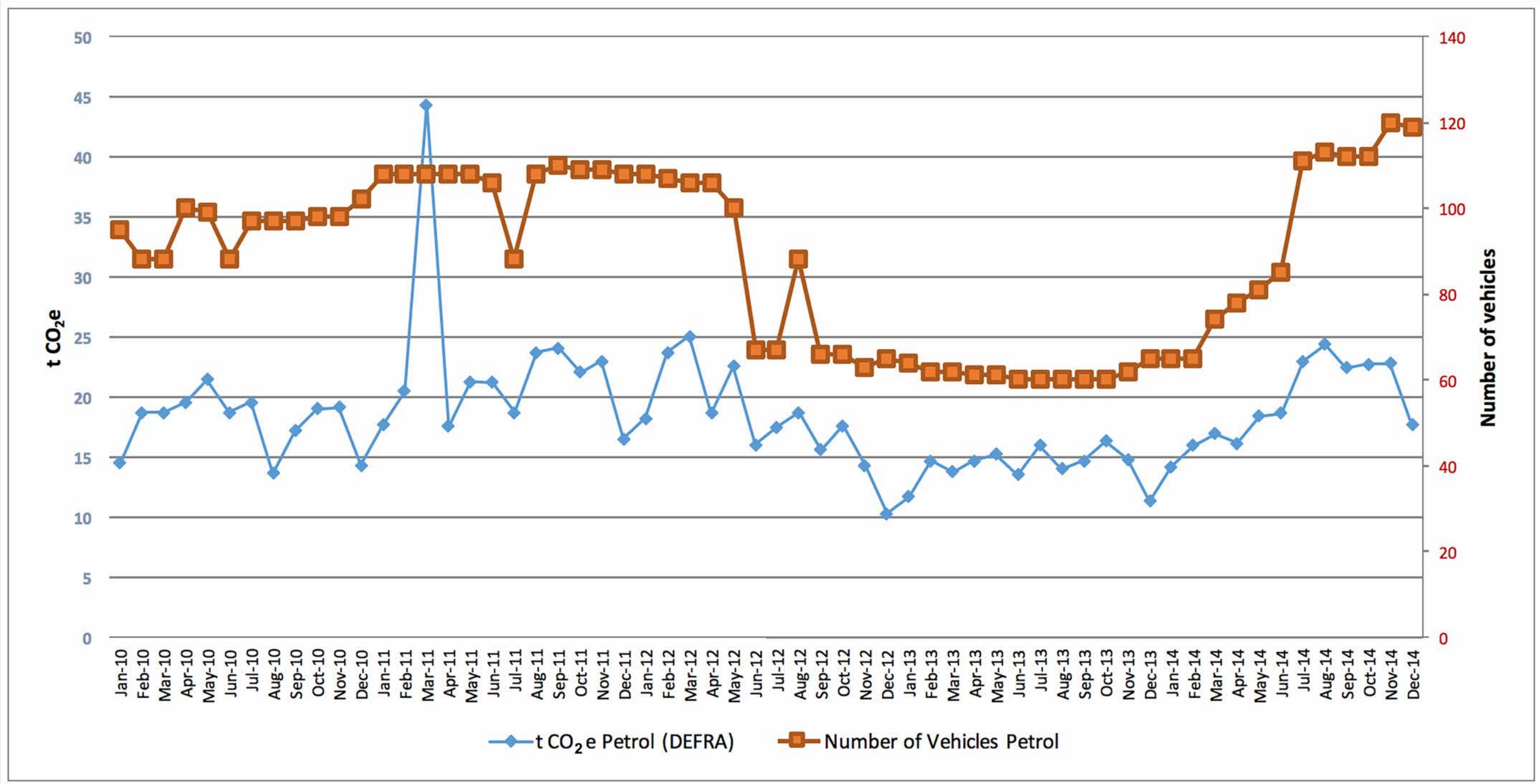


Figure 4.8 **Petrol CO_2e emissions (DEFRA) and number of available vehicles**

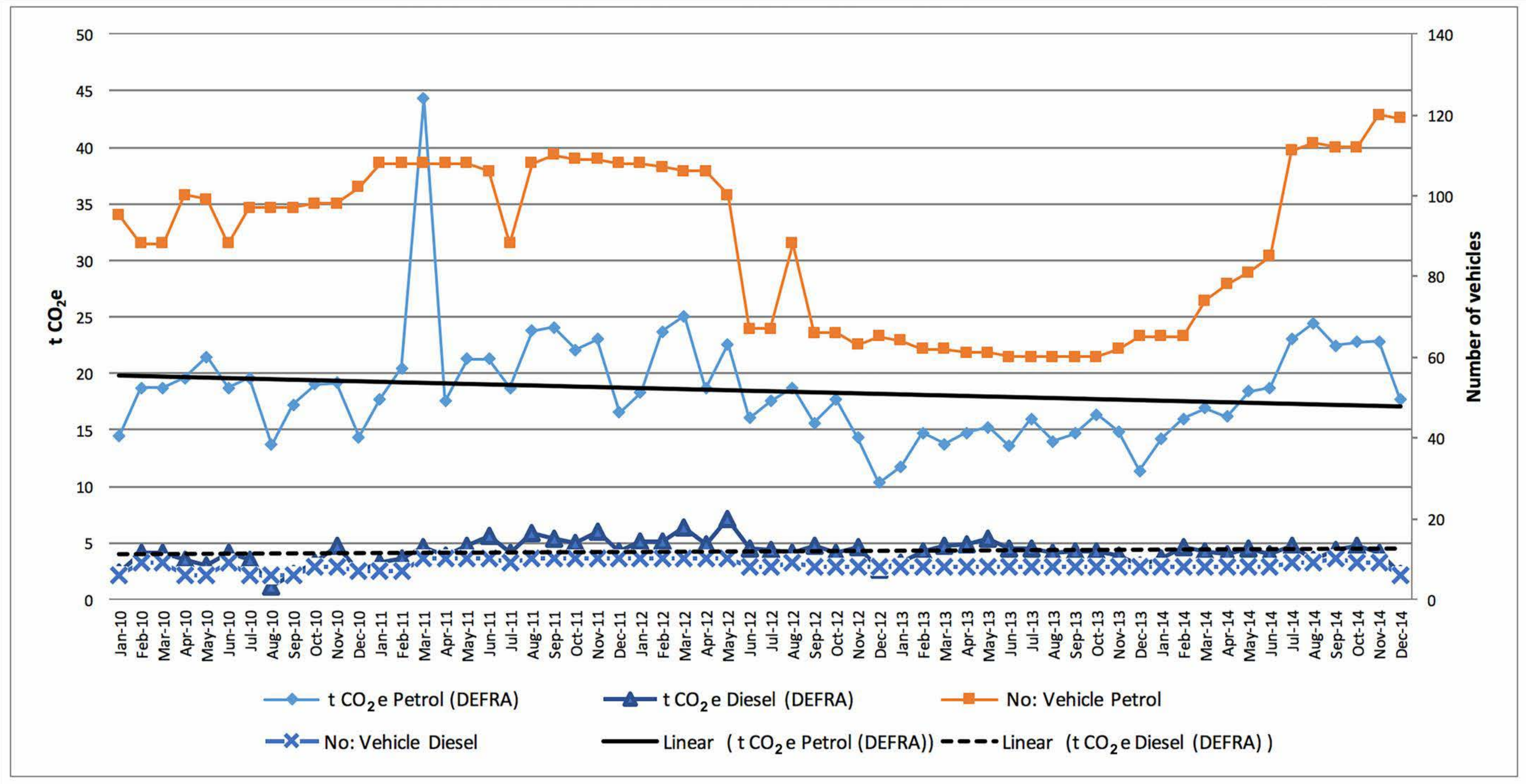


Figure 4.9 **Comparison between Petrol and Diesel t CO_2e (DEFRA) in relation to the total number of vehicles**

The comparison between WRI GHG Protocol and DEFRA methodology for petrol CO_2e emissions from 2010 to 2014 is presented in Table 4.3. The total CO_2e emissions difference between these methodologies was 15 t CO_2e emissions (1107 t CO_2e – 1092 t CO_2e). In contrast, the total diesel CO_2e emissions obtained by using WRI GHG Protocol was 248.8 t CO_2e while the DEFRA methodology was 251.70 showing a difference to 2.9 t CO_2e emissions (251.7 t CO_2e -248.8 t CO_2e) (Table 4.4).

Table 4.3 **Petrol CO_2e emissions comparison of WRI GHG Protocol with DEFRA**

Years	t CO_2e Petrol (DEFRA)	t CO_2e Petrol (GHG)
2010	215	211
2011	270	269
2012	218	214
2013	171	167
2014	233	230
Total	**1107**	**1092**

Table 4.4 **Diesel CO_2e emissions comparison WRI GHG Protocol with DEFRA**

Years	t CO_2e Diesel (DEFRA)	t CO_2e Diesel (GHG)
2010	38.42	36.43
2011	56.18	55.59
2012	57.50	57.06
2013	50.88	50.93
2014	48.71	48.87
Total	**251.70**	**248.88**

Figure 4.10 and Figure 4.11 present monthly CO_2e emissions for petrol and diesel vehicles calculated by using DEFRA and WRI GHG Protocol methodologies respectively. Figure 4.10 does not show visual correlation in monthly CO_2e emissions that might be attributed to similar emission factors of WRI GHG Protocol methodology and that of DEFRA. The petrol CO_2e trend line shows a downward trend, which maybe also be attributed to the service provider re-calling the vehicles due to non-payment.

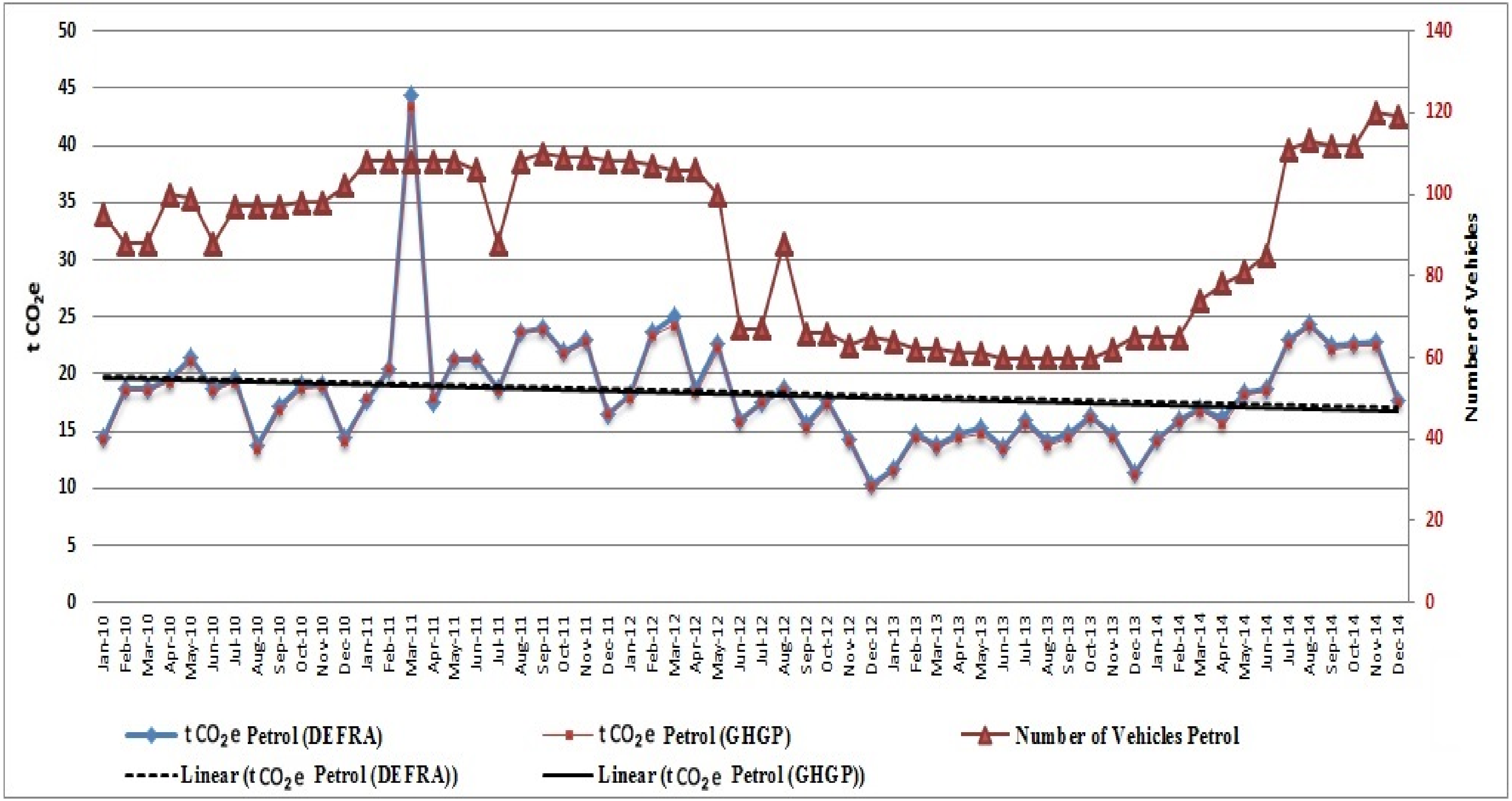


Figure 4.10 **Comparison of DEFRA and GHG Protocol petrol CO_2e emissions with total vehicle number from January 2010 to December 2014**

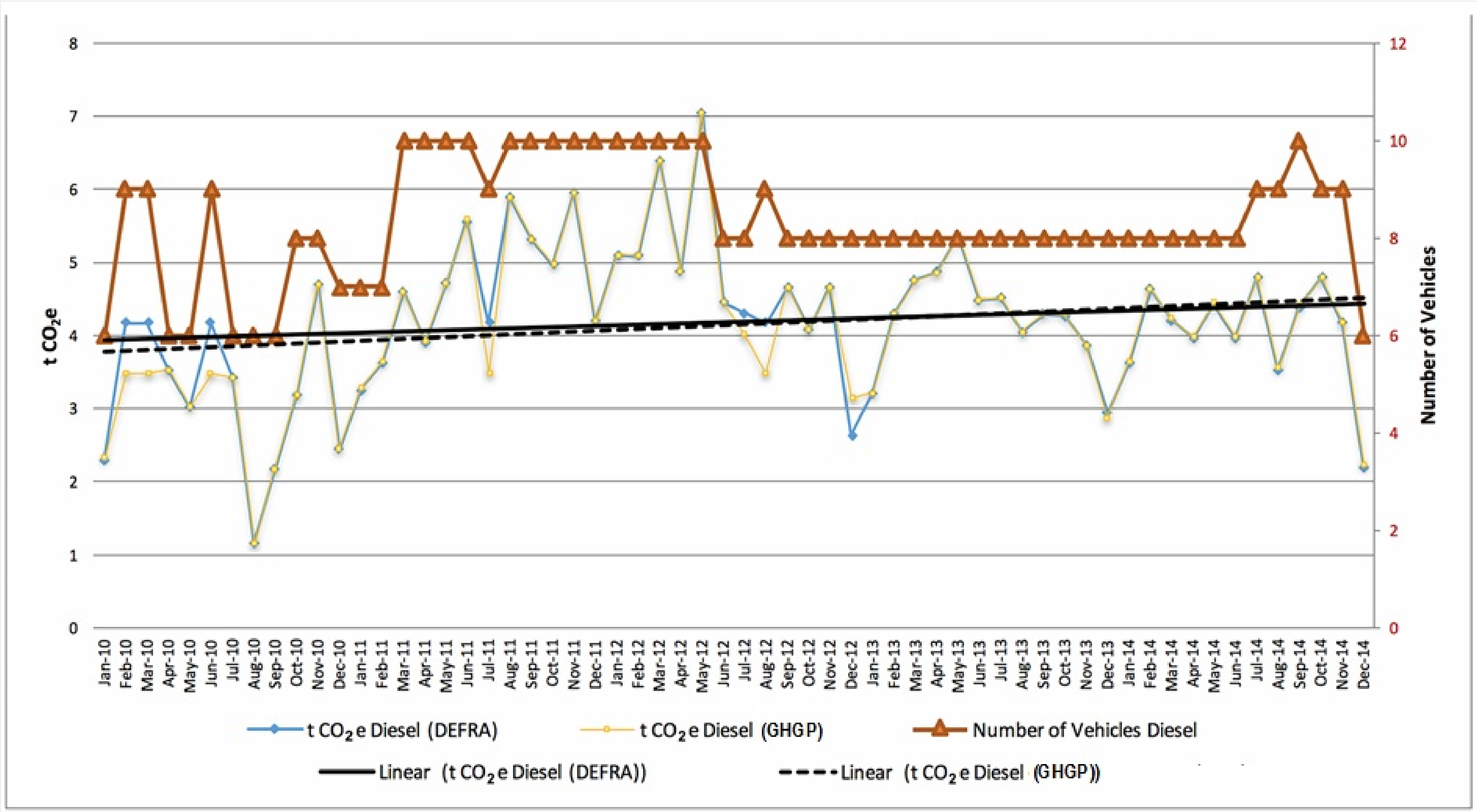


Figure 4.11 **Comparison of DEFRA and GHG Protocol diesel CO_2e emissions with total vehicle number from January 2010 to December 2014**

Figure 4.11 shows visual correlation in CO_2e emissions (February 2010, March 2010, June 2010, July 2011 and August 2010) between DEFRA and WRI GHG Protocol methodologies, which may be attributed to the missing months in which an averaged CO_2e emissions was used. The visual difference in December 2012 is due to an average fuel CO_2e values used because of missing fuel information. The diesel CO_2e emissions trend shows an upward trend, possibly due to more diesel vehicles being used for health services when the service provider re-called mostly petrol vehicles.

4.1.8 CO_2e emission profile of vehicle manufacturer

Government fleet vehicles contribute 4% of the total carbon footprint of Ekurhuleni Health District. Fleet vehicles are used daily in rendering health services to the communities, provincial health facilities and district offices. Figure 4.12 shows that 40% of vehicles were Volkswagen, which release the highest emissions of 519 t CO_2e in accordance with its representative fleet quantity. Nissan accounts for almost 19% of the vehicles and emitted 272 t CO_2e. The higher CO_2e emissions from Volkswagen and Nissan are ascribed to the higher vehicle percentages in the government fleet. Although Iveco accounts for only 4% of the vehicles, it had the third highest emissions of 130 t CO_2e. This may be due to the vehicles using diesel fuel, which has a higher emission factor than petrol and has a higher engine capacity. For example, in 2014 DEFRA reported a diesel emission factor of 2.669 kg/t CO_2e, while the petrol emission factor was 2.299 kg/t CO_2e (see Table 3.4).

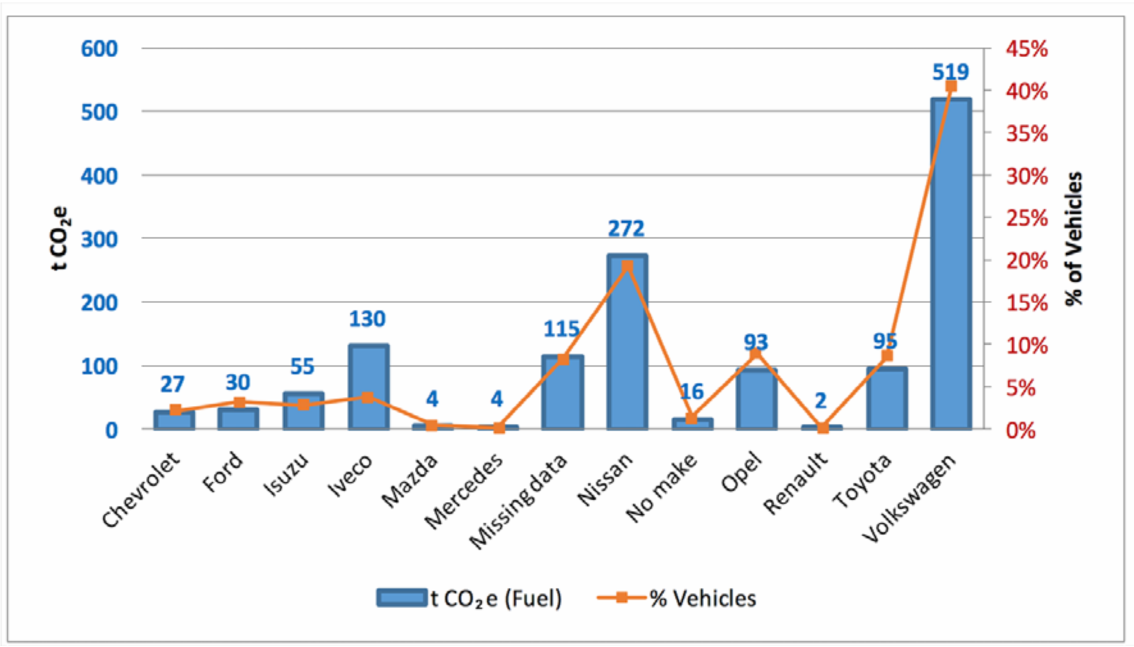


Figure 4.12 **Make and quantity CO_2e emissions of fleet vehicles**

In terms of missing data, average t CO_2e emissions were used in missing months (February 2010, March 2010, June 2010, July 2011 and August 2012), which accounts for 8% of the vehicles and 115 t CO_2e. Toyota, Opel and Isuzu produced 95, 93 and 55 t CO_2e emissions respectively. The rest of the combined emissions of the vehicles was 83 t CO_2e, in which "No make" accounts for 16 t CO_2e. "No make" are the number of vehicles for which fuel information was available, but the vehicle model/make were missing, as explained in Chapter 3 (3.6.1).

The top three vehicle CO_2e emitters in relation to the percentage number of vehicles in Ekurhuleni Health District from January 2010 to December 2014 were Volkswagen, Nissan and Iveco (Figure 4.12). The higher CO_2e emissions from Volkswagen and Nissan are credited to the higher number of these brands in the government vehicle fleet associated with CO_2e emissions. Iveco is a vehicle using diesel fuel, which has a higher emission factor than petrol and a higher engine capacity resulting in higher fuel consumption.

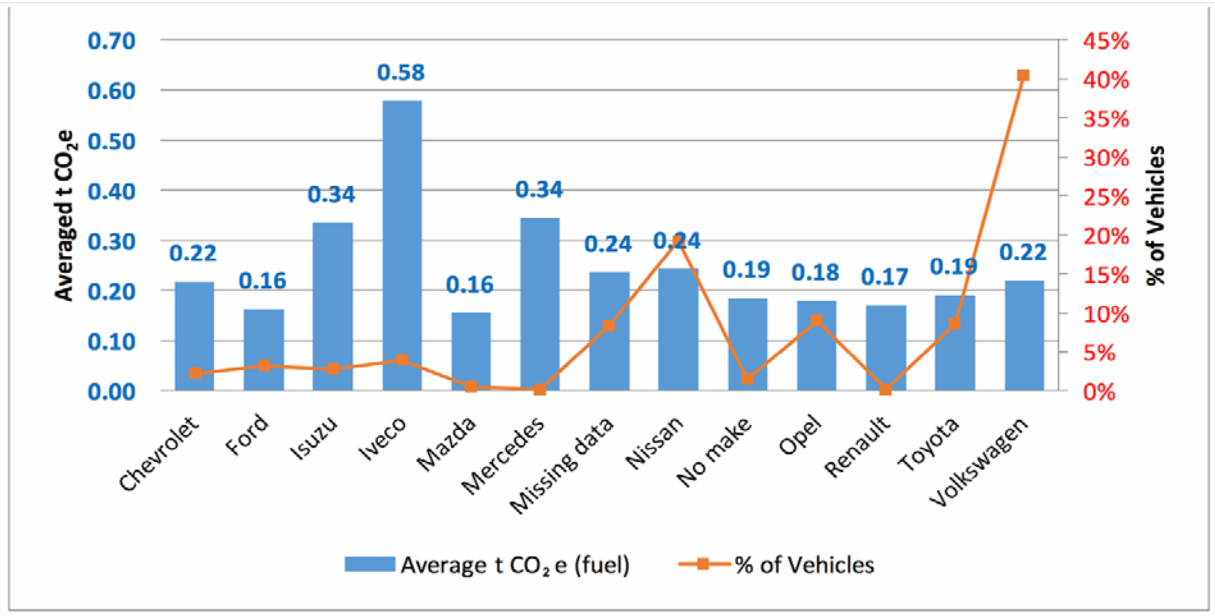


Figure 4.13 **Fleet vehicles make and average CO_2e emissions**

Considering the average CO_2e emissions (CO_2e emissions divided by the number of vehicles), the highest emitting vehicles in terms of average CO_2e emissions were IVECO, Mercedes and Isuzu are tied in the second and third place (Figure 4.13). These vehicles have a higher engine capacity and use diesel fuel, which has a higher CO_2e emission factor than that of petrol.

4.1.9 Model of vehicle and CO_2e emission profile

Each vehicle manufacturer offers different models. Therefore, it is essential to explore further and determine the CO_2e contribution of the various models. In this section Volkswagen and Nissan models are examine in more detail because, at the time of the study, these vehicles accounted for 59% of the total government fleet vehicles in Ekurhuleni Health District.

Figure 4.14 shows an analysis of different Volkswagen models. It is observed that, Polo 1.4 Trendline H/B accounts for 24% of the Volkswagen models and contributed the highest quantity of emissions of 132 t CO_2e, followed by Polo Vivo 1.4 Concept, which accounts for 18% of the Volkswagen models and emitted 76 t CO_2e, and Polo Classic 1.4 Trendline released 74 t CO_2e and accounts for 15% of the Volkswagen vehicles. Polo 1.6 Trendline accounts for 13% and produced 62 t CO_2e, while Citi Golf 1.4 discharged 54 t CO_2e and accounts for 12% of the Volkswagen models. The combined CO_2e emissions for the other model was 122 t CO_2e and accounts for 18% of the models.

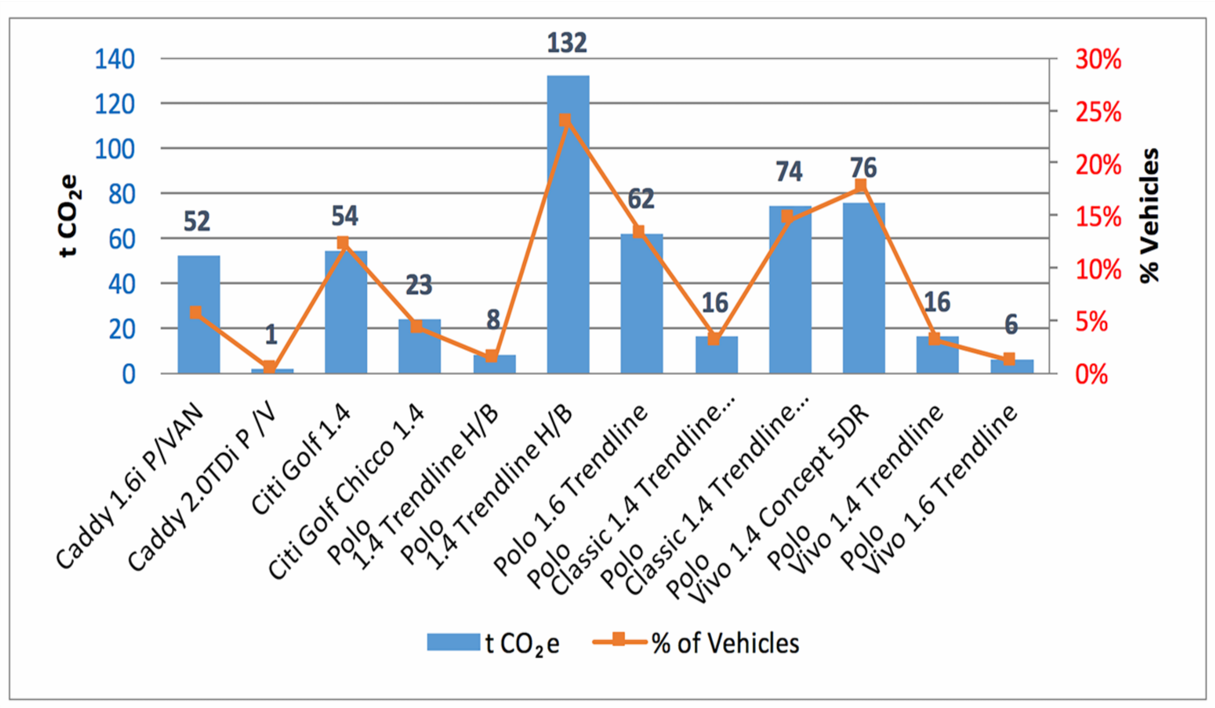


Figure 4.14 **Different models of Volkswagen vehicles and their associated CO_2e emissions**

Considering the average CO_2e emissions for the Volkswagen model, the most CO_2e efficient models are Polo Vivo 1.4 Concept 5DR, Citi Golf 1.4 and Polo 1.6 Trendline and Caddy 2.0 TDI P/V (Table 4.5).

Table 4.5 **Efficiency of CO_2e emissions by Volkswagen vehicle models**

Model	**Average t CO2e/ L (fuel)**	**% of Vehicles**
Polo vivo 1.4 concept 5dr	0.18	17.7%
Citi golf 1.4	0.19	12.1%
Polo 1.6 Trendline	0.20	13.3%
Caddy 2.0TDi P /V	0.20	0.3%
Polo Classic 1.4 Trendline	0.21	3.1%
Polo Classic 1.4 Trendline S/D	0.21	14.6%
Polo Vivo 1.6 Trendline	0.22	1.1%
Polo Vivo 1.4 Trendline	0.22	3.1%
Polo 1.4 Trendline H/B	0.24	23.9%
Citi Golf Chicco 1.4	0.24	4.2%
Polo 1.4 Trendline	0.26	1.3%
Caddy 1.6i P/VAN	0.40	5.4%
Grand mean/total	**0.22**	**100.0%**

Table 4.6 **Most efficient and least efficient CO_2e emitters for Nissan vehicle models**

Model	**Average t CO_2e/L (fuel)**	**% of Vehicl**
Micra 1.4	0.15	16.53%
Nissan 1400 LDV	0.17	1.61%
Livina 1.6 Acenta (H84)	0.19	12.15%
Tiida 1.6 Visia	0.20	13.23%
Hardbody NP300 2.4i D/C 4X2 (K13/K31)	0.21	1.43%
Nissan Hardbody 2.4i Hi-Rider	0.26	40.39%
Hardbody 2.4i Scab LWB	0.30	9.83%
Nissan NV350 2.5P wide taxi 16-seater mini bus	0.36	0.36%
Primastar 1.9 DCI 9 Seater	0.58	4.47%
Grand mean/total	**0.24**	**100.00%**

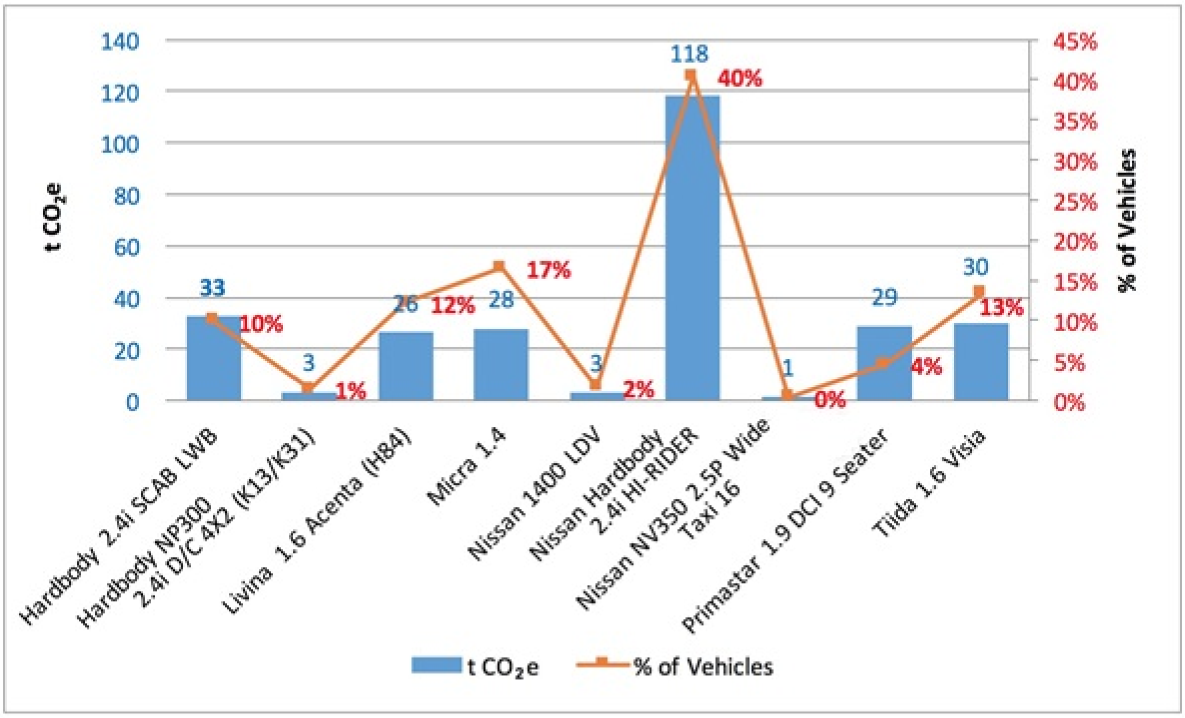


Figure 4.15 **Different models of Nissan vehicles and associated CO_2e emissions**

The most efficient Nissan models in terms of the average CO_2e are Micra 1.4, Nissan 1400 LDV and Livina 1.6 Acenta (H84) (Table 4.6). Figure 4.15 shows the Nissan vehicle breakdown per model. Nissan Hardbody 2.4 Hi-Rider emits 118 t CO_2e and accounts for 40% of the Nissan models; followed by Hardbody 2.4i SCAB LWB that produced 33 t CO_2e and accounts for 10% of Nissan vehicles; Tida 1.6 Visia emits 30 t CO_2e ,which accounts for 13%; and Primastar 1.9 DCL 9-Seater and Micra 1.4 emitted 29 and 28 t CO_2e respectively and accounts for 4% and 17% of the Nissan vehicles; and Livina 1.6 Acenta (H84) produced 26 t CO_2e and accounts for 12%. The rest of the models account for 4% of the Nissan vehicles and produced 7 t CO_2e.

4.2 SCOPE 2: CARBON FOOTPRINT OF ELECTRICITY

Scope 2 covers the direct emissions associated with electricity consumptions. As elaborated in Chapter 3 (3.6.2), the Finance Department in the Ekurhuleni Health District is responsible for paying electricity bills for provincial health clinics and the District Office. Kilowatts of electricity consumed by the provincial health clinics and district office were obtained from invoices supplied by the Finance Department. However, most of the provincial health clinics share facilities with the municipal clinics. In cases where a facility is shared between the two spheres of government (provincial and municipal clinics), an arrangement was made between these two parties that the municipal health facilities will pay for the electricity used in shared buildings.

Considering the unavailability of invoiced data from the municipality, the electricity consumption data were partially available from only three facilities, namely Nokuthela Ngwenya Clinic, Northmead Clinic and the District Office. In order to compensate for the missing data of ten provincial clinics, it was necessary to extrapolate the data by (1) averaging the available kilowatts data from the two provincial facilities (Nokuthela Ngwenya Clinic and Northmead Clinic) and (2) multiplying these average kilowatts by Eskom emission factors (see Table 3.8) for sold and generated for the specific financial year in question.

Table 4.7 **Total CO_2e emissions from electricity (sold and generated) consumption from January 2010 to December 2014**

Facility	t CO_2e Sold	t CO_2e Generated
District Office	4117	3920
Nokuthela Ngwenya	3885	3699
Northmead	344	327
Isabella	2680	2553
Esangweni	2680	2553
Mary Moodley	2680	2553
Jabulani Dumani	2680	2553
Phola Park	2680	2553
Ramakonopi	2680	2553
Phillip Moyo	2680	2553
Andries Radisela	2680	2553
Kwa-Temba	2680	2553
Magagula	2680	2553
Total	**35150**	**33474**

Where the monthly electricity consumptions of a specific facility was not available, such as the District Office (January 2010 – December 2011; April 2012 - November 2012; April 2013 - November 2013 and March 2014 – November 2014), Nokuthela Ngwenya Clinic (January 2010 – December 2011; September & October 2013 and August 2014) and Northmead Clinic (January 2010 – December 2014; November & December 2013; May 2014 and July 2014 –

October 2014), it was necessary to extrapolate the missing months. This was done by obtaining an average kilowatts derived from the available information for the specific facility and multiplied by Eskom emission factors (see Table 3.8) for sold and generated for that specific financial year in question.

The total CO_2e emissions from electricity sold and electricity generated from January 2010 to December 2014 were 35150 t CO_2e and 33474 t CO_2e respectively (Table 4.7). The CO_2e emissions of electricity generated is the total emissions of production of electricity, while the CO_2e emissions of electricity sold includes production and distribution of the electricity to the clients. Reference is made to the sold CO_2e emission in this study.

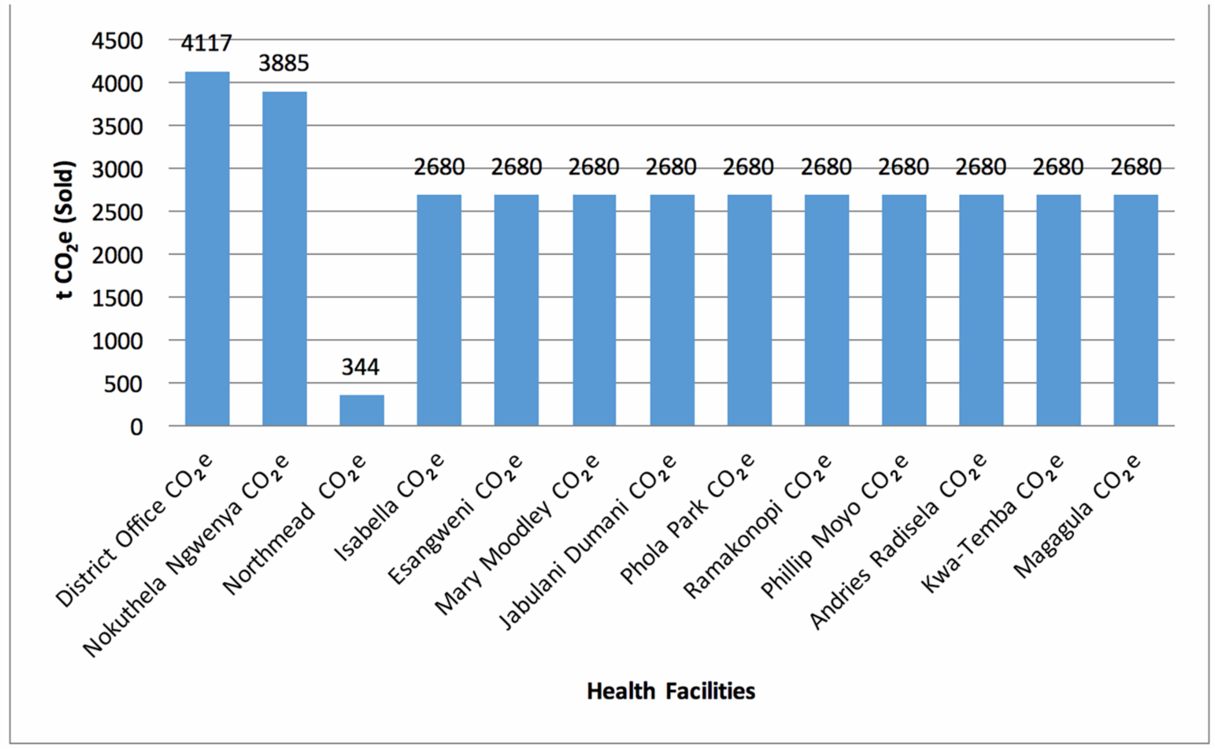


Figure 4.16 **CO_2e emissions from electricity sold to facilities during January 2010 to December 2014**

Figure 4.16 illustrates that, the highest CO_2e emissions was from the District Office (4117 t CO_2e), followed by Nokuthela Ngwenya (3885 t CO_2e) and the lowest CO_2e emissions was from Northmead (344 t CO_2e). The CO_2e emissions of the remaining extrapolated facilities were constant at 2680 t CO_2e, which is attributed to an average kilowatts of electricity consumption used to calculate the CO_2e emissions due to lack of data.

The monthly electricity CO_2e emissions are presented in Figure 4.17. The District office and Nokuthela Ngwenya CO_2e emissions from January 2010 to March 2011 shows constant CO_2e emissions. This may be accredited to an average kilowatts derived from the available information for the specific facility used to calculate the CO_2e emissions. The slight decrease in CO_2e emissions from April 2011 to December 2011, is due to a lower Eskom emission factor used in that financial year (1.03 CO_2e/t) in comparison to a higher Eskom emission factor used in January 2010 to March 2011 (1.05 CO_2e/t). The CO_2e emissions trend lines for the District Office and Nokuthela Ngwenya show slightly upward trends, which may suggest a current under estimate of CO_2e emissions.

Figure 4.17 shows a possible CO_2e emission trend. The District Office shows an increase of 23 t CO_2e emissions in January 2012 to February 2012 and slight increase of 1 t CO_2e from January 2014 to February 2014. Lastly, there was a small noticeable increase from January 2013 to February 2013, plausibly due to employees coming back from holiday. There was a slight decrease in emissions from December 2012 to January 2013 (8 t CO_2e) and from December 2013 to January 2014 (6 t CO_2e). This may possibly be as a result of the employees going on holiday during December and early January. The District Office CO_2e emissions are constant for these months, January 2010 – December 2011, April 2012 - November 2012, April 2013 - November 2013 and March 2014 – November 2014, because of the average kilowatts of electricity consumption used to calculate the CO_2e emissions due to lack of data as explained earlier.

Nokuthela Ngwenya shows possible CO e emission trends. There is a gradual increase in CO_2e emissions in March to June in most years (2012, 2013 & 2014), which maybe be attributed to heating requirements in autumn and winter seasons. The CO_2e emissions decreased in spring and summer in most years, for instance in August – December 2012 and 2013, as well as in September 2014 to December 2014, when the facilities use less electricity due to the warmer summer climate.

The emissions of CO_2e for Northmead from January 2010 to December 2013 and from July 2014 to October 2014 show a constant emission (Figure 4.17). This is attributed to the average kilowatts of electricity consumption used to calculate the CO_2e emissions due to limitation of data. The CO_2e emissions shows a visual peak in March 2012, June 2012 and November 2014, which is likely to be associated with increased power consumption in early autumn (March) and winter (June). While the reason for the increase in November is not certain at the time of writing.

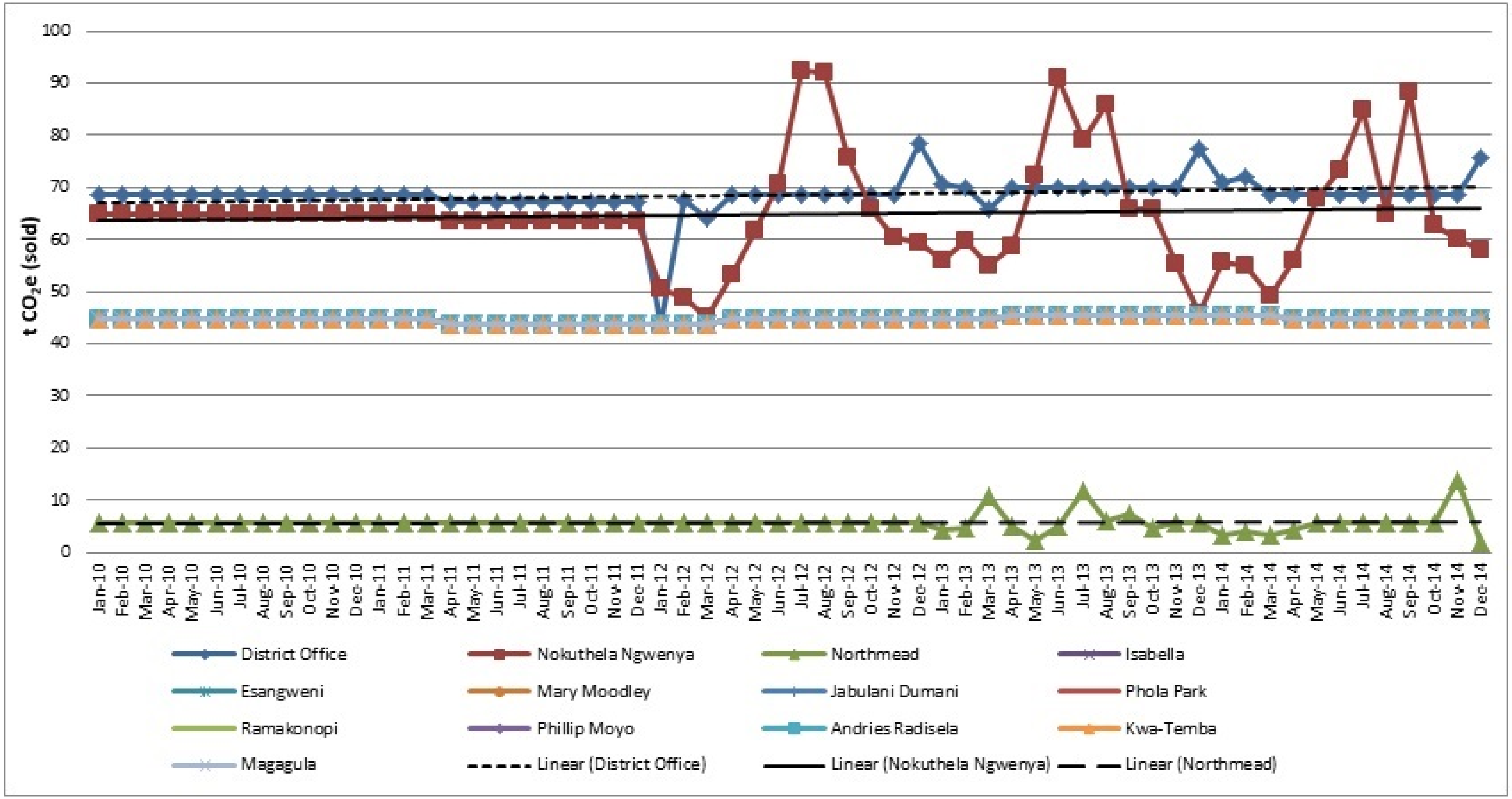


Figure 4.17 **CO_2e emissions sold to facilities during January 2010 to December 2014**

The rest of the facilities, including Isabella, Esangweni, Mary Moodley, Jabulani, Dumani, Phola Park, Ramokonopi, Phillip Moyo, Andries Radisela, Kwa-Themba and Magagula shows a constant CO_2e emission attributed to the average kilowatts of electricity used to calculate the CO_2e emissions due to data limitation.

4.3 SCOPE 3: CARBON EMISSIONS OF OFFICE PAPER

Scope 3 covers the indirect emissions associated with activities or services that includes the consumption of office paper during official activities. As described in Chapter 3, data for A4 office paper used by employees in Ekurhuleni Health District and provincial facilities were collected for the period of April 2010 to December 2014. In order to calculate the five (5) years footprint of CO_2e emissions for office paper from January 2010 – December 2014, the average number of boxes of paper was used and applied to the missing data from January 2010 to March 2011.

Figure 4.18 illustrates the number of Sappie (A4) boxes used and its associated CO_2e emissions from January 2010 to December 2014. A Sappie emission factor (1.94 CO_2e /t), which includes electricity was used to quantify the CO_2e emissions of office paper. The highest office paper consumption occurred in February 2013 and August 2014, using 304 and 322 office paper boxes, which produced 7.3 and 7.7 t CO_2e emissions respectively.

No office paper had been dispatched to the health facilities in September 2011 and 2012 and March 2012 and 2013 as the health facilities still had stock from previous orders. The steady increases shown in the CO_2e emission trend from January 2010 – March 2011 is attributed to the unavailability of Sappie office paper data for that period. An averaged CO_2 emission was used that was derived from the collected available paper data.

The financial year of Ekurhuleni Health District is divided into four quarter, namely quarter 1 April – June, quarter 2 July – September, quarter 3 October – December and quarter 4 January- March. The new financial year begins in quarter 1. Figure 4.18 displays a possible CO_2e mission trends based on the different quarters.

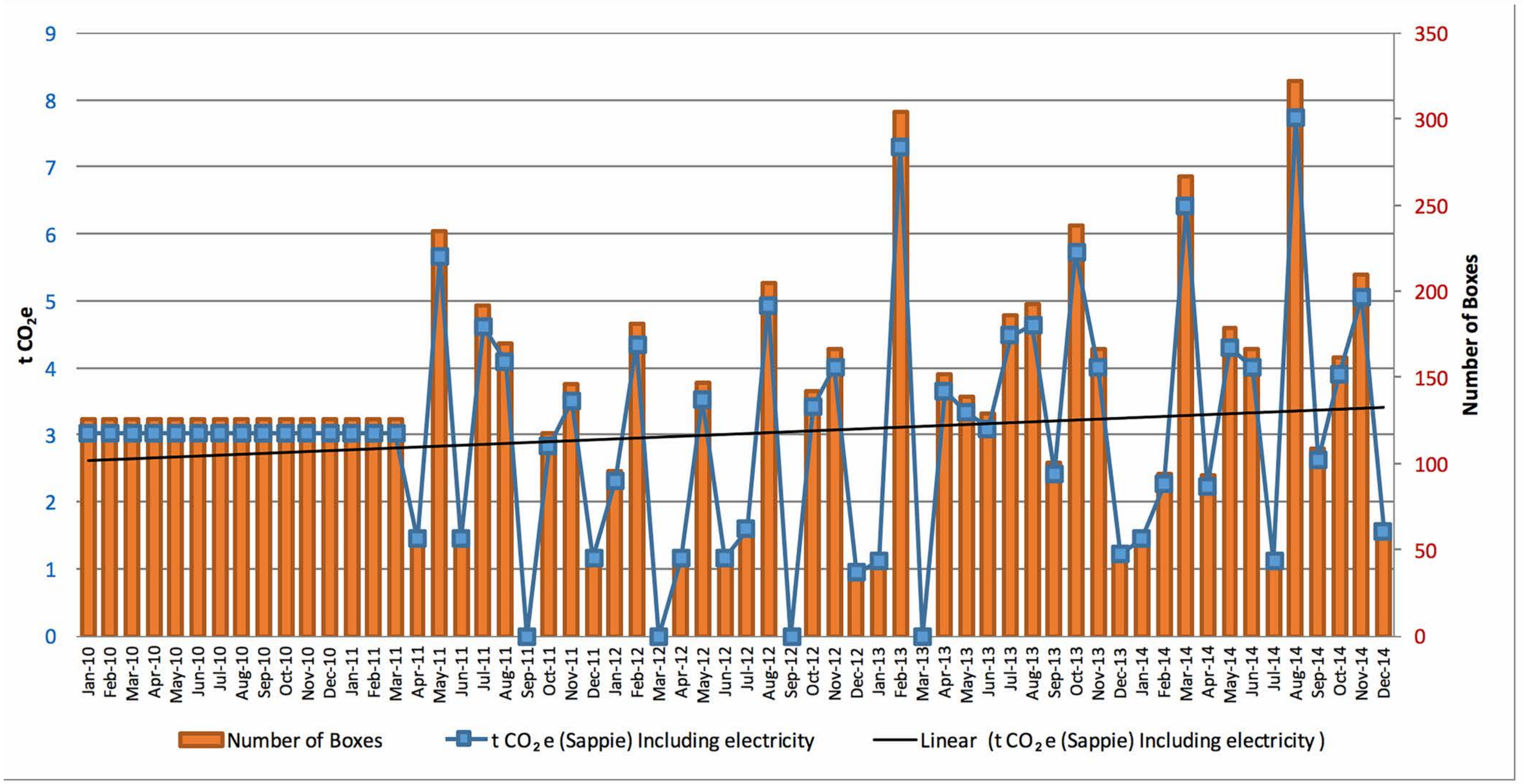


Figure 4.18 **Amount of office paper used and its associated CO_2 emissions from January 2010 to December 2014**

There was a slight increase in the paper use CO_2e emissions in the first two months in Quarter 2, July and August 2011-2014, and a slight decrease in September 2011-2014. In addition, the first two months in Quarter 3 (October & November) of 2011, 2012 and 2014 showed an increase in CO_2e emissions and decrease in December. There was an increase in the paper use emissions the first two months in Quarter 4 (January and February) and a decrease in March 2013. The increase in the office paper CO_2e use in the first two months of the above mentioned quarters may be attributed to an increase the writing of reports or other administration activities to meet quarterly targets. The upward trends in the CO_2e emissions, was thus probably due to an increase in administration activities.

The CO_2 emissions associated with the use of Sappie office paper can be quantified based on emission factors that includes electricity or excludes electricity. Table 4.8 shows the various CO_2 emissions based on the application of these two emission factors. The total CO_2 emissions was 181 t CO_2e including electricity and 169 t CO_2e excluding electricity, showing a difference of 12 t CO_2e. In this study, the Sappie emission factor including electricity was used to calculate the overall CO_2 emission of office paper.

Table 4.8 **Office paper CO_2e emissions based different emission factors for Sappie annually**

Year	**t CO_2e including electricity**	**t CO_2e excluding electricity**	**Number of boxes**
2010	36	34	1512
2011	34	32	1407
2012	27	26	1139
2013	41	38	1707
2014	43	40	1775
Total	**181**	**169**	**7540**

A total of 7540 boxes were used from January 2010 to December 2014 that accounts for a total 181 t CO_2e emissions. The highest paper use CO_2 emissions occurred in 2014 equating 43 t CO_2e emissions. The lowest emission occurred in 2012 producing 27 t CO_2e emissions.

Considering the availability of the office paper emission factors from different manufacturers (Sappi and Mondi), it is opportune to compare the CO_2 emissions between these manufacturers. Table 4.9 compares the annual office paper CO_2 emissions between Sappie and

Mondi based on emission factors which include electricity. The total CO_2 emissions of Sappie office paper (181.5) is much lower in comparison to Mondi (424.9). The higher CO_{2e} emissions of Mondi office paper may be attributed to higher reported emission factor of 4.54 t CO_2e in comparison to Sappie with emission factor of 1.94 t CO_2e including electricity. If Ekurhuleni Health District office were using Mondi office paper instead of the Sappie, the overall CO_2e emission would have been approximately 43% higher.

Table 4.9 **Comparison of Sappie and Mondi CO_2 emissions annually based on emission factor including electricity**

Year	t CO_2e (Sappie) including electricity	t CO_2e (Mondi) including electricity
2010	36.4	85.2
2011	33.9	79.3
2012	27.4	64.2
2013	41.1	96.2
2014	42.7	100.0
Total	**181.5**	**424.9**

Moreover, Figure 4.19 shows a detailed monthly comparison between Sappie and Mondi CO_2e emissions based on the emission factor including electricity. There is a visual difference in the CO_2 emissions between Sappie and Mondi in each month. CO_2e emissions of Mondi are much higher when compared with Sappie, which may be attributed to higher emission factor of 4.54 t CO_2e including electricity. The CO_2e emission shows a sharp upward trend of Mondi and slight increase CO_2e emission of Sappie, which might be attributed to the difference in emission factors. This result illustrates the importance of the paper industries to implement carbon emission reduction measures on energy use.

Figure 4.20 and Table 4.10 show a comparison of Sappi with Mondi CO_2e emissions based on the emission factor excluding electricity. The total Sappie CO_2e emission (169 t CO_2e) was higher in comparison to Mondi (157 t CO_2e), showing a difference of 12 t CO_2e emission (Table 4.10). There is a slight increase in the CO_2e emissions for both Sappie and Mondi (Figure 4.20).

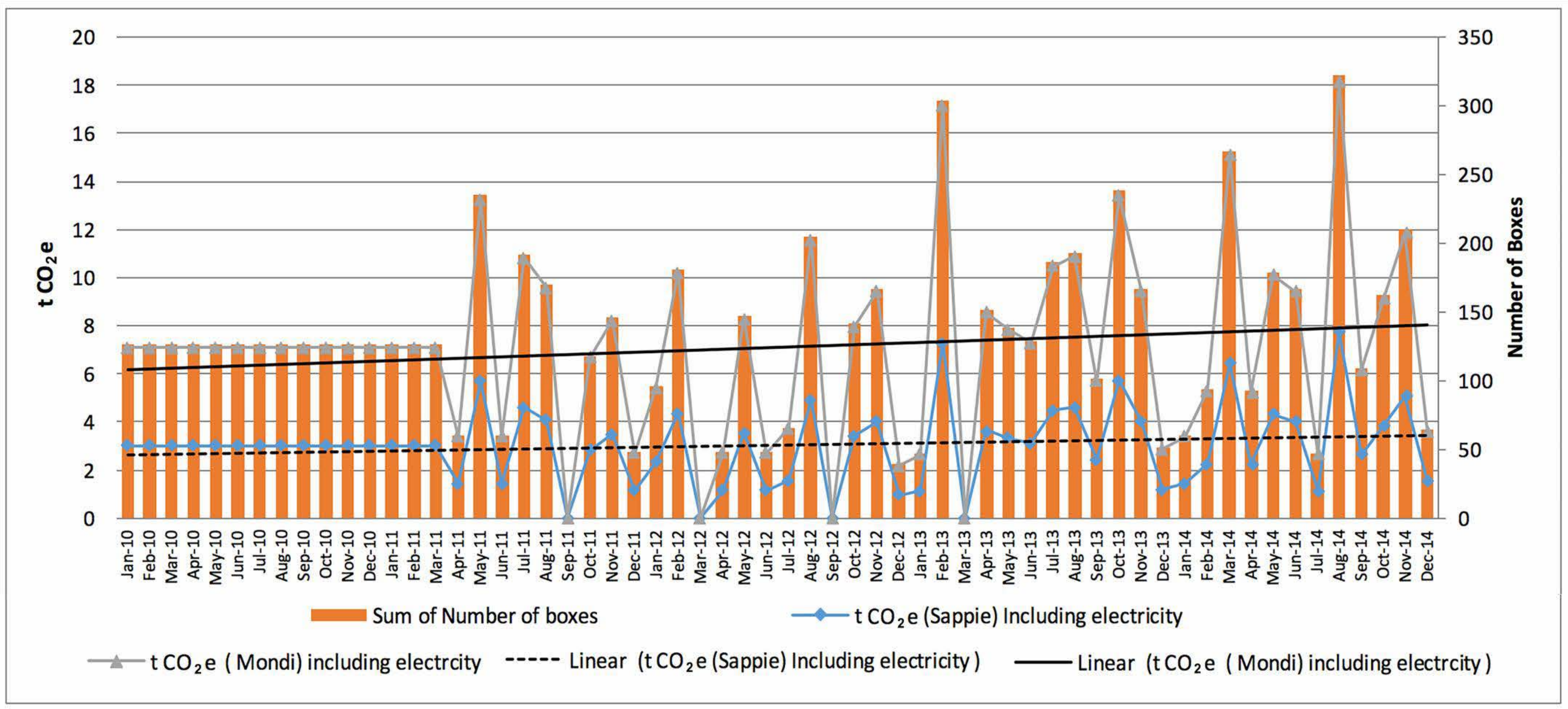


Figure 4.19 **Monthly comparison between Sappie and Mondi CO_2e emissions based on emission factor including electricity**

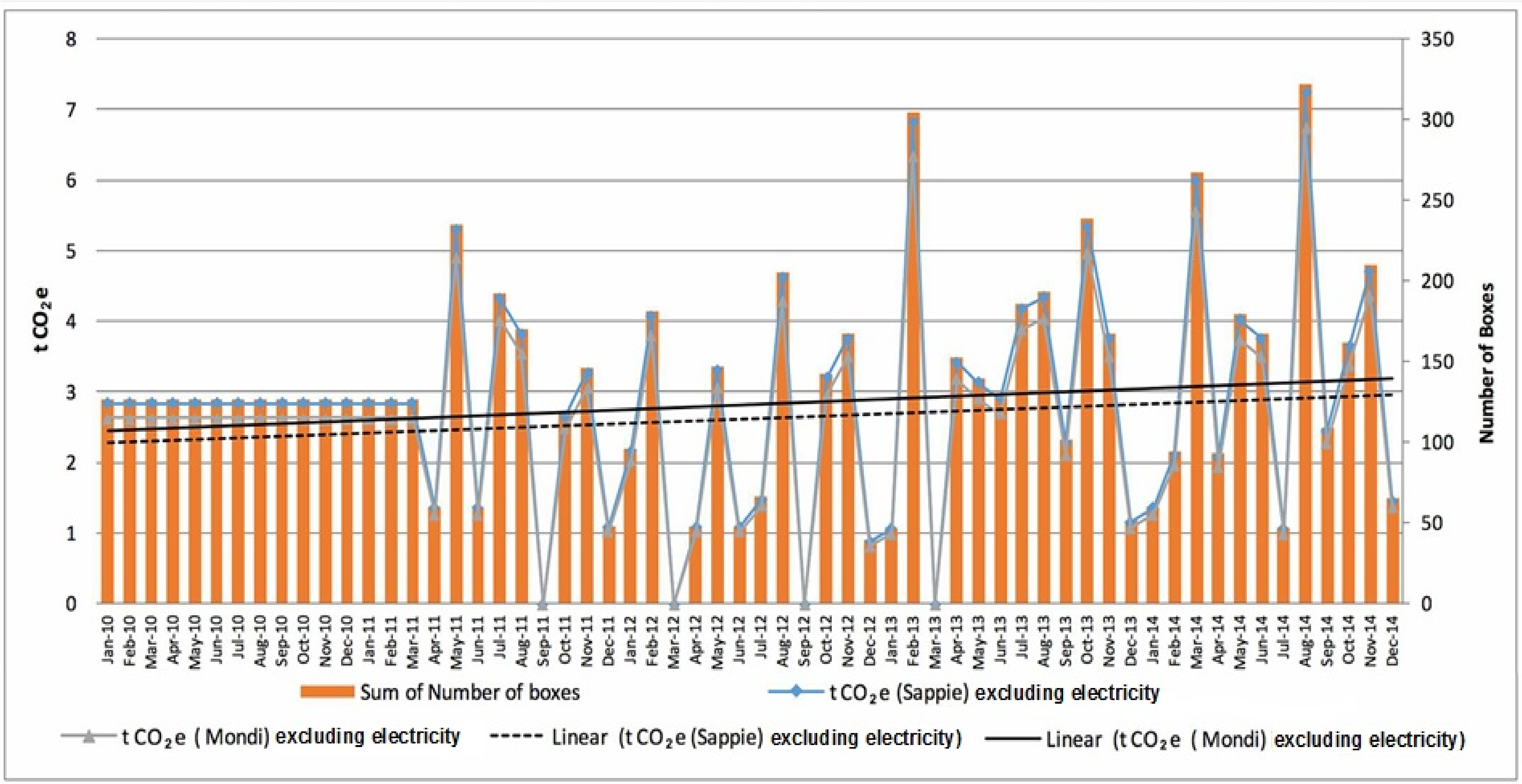


Figure 4.20 **Monthly comparison of Sappie and Mondi CO_2e emissions based on emission factor excluding electricity**

Table 4.10 **Comparison between Sappi and Mondi CO_2e emissions based on emission factor excluding electricity**

Year	**t CO_2e (Sappie) excluding electricity**	**t CO_2e (Mondi) excluding electricity**
2010	34	32
2011	32	29
2012	26	24
2013	38	36
2014	40	37
Total	**169**	**157**

4.4 SCOPE 3: CARBON EMISSION OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

Scopes 3 encompass the indirect emissions associated with activities and the CO_2e emissions associated with the use of information and communication technology (ICT). ICT equipment covered in this section includes laptops, Central Processing Units (CPU), desktop monitors, printers and cell phones. ICT equipment information was obtained from the Information Technology (IT) unit within Ekurhuleni Health District Office. The carbon footprint of these ICT entities was analysed using the Life Cycle Stage Ration Profiling methodology, as indicated in a published guideline by Greenhouse Gas Protocol (2012a).

Table 4.11 **Annual ICT carbon emissions**

Year	**t CO_2e**
2010	172.48
2011	169.19
2012	172.48
2013	175.76
2014	172.48
Total	**862.39**

Table 4.11 shows the annual carbon emissions associated with ICT. The highest emissions occurred in 2013 producing 176 t CO_2e and the least occurred in 2011 emitting 169 t CO_2e. This may be the result of Eskom reporting a higher emission factor in April 2013 to March 2013 (1.07kg CO_2e/ KWh) (Eskom, 2013) and lower emission factor in April 2011 to March 2012 (1.03kg CO_2e/KWh) (Eskom, 2012). In 2010, 2012 and 2014 the carbon emission was constant at 173 t CO_2e, because of the possible unavailability of the Eskom emission factor

in which a default emission factor (1.05kg CO_2e/KWh) was obtained by averaging the available emission factors (Table 3.8).

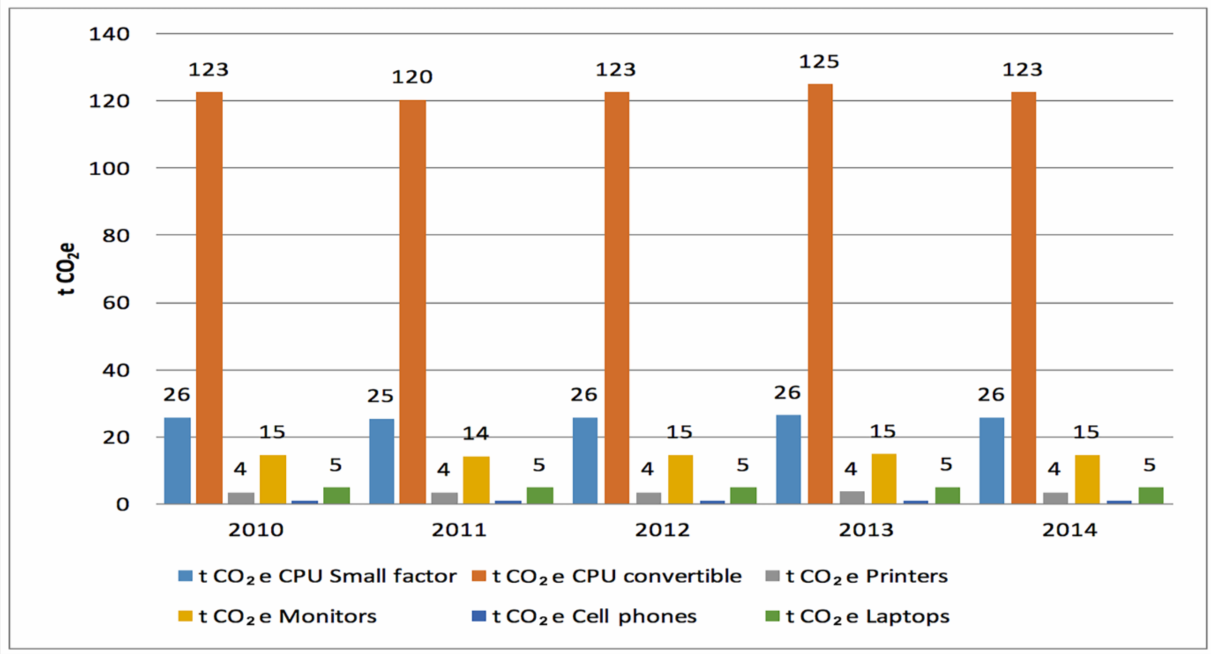


Figure 4.21 **Breakdown of ICT CO_2e emissions equipment into different years**

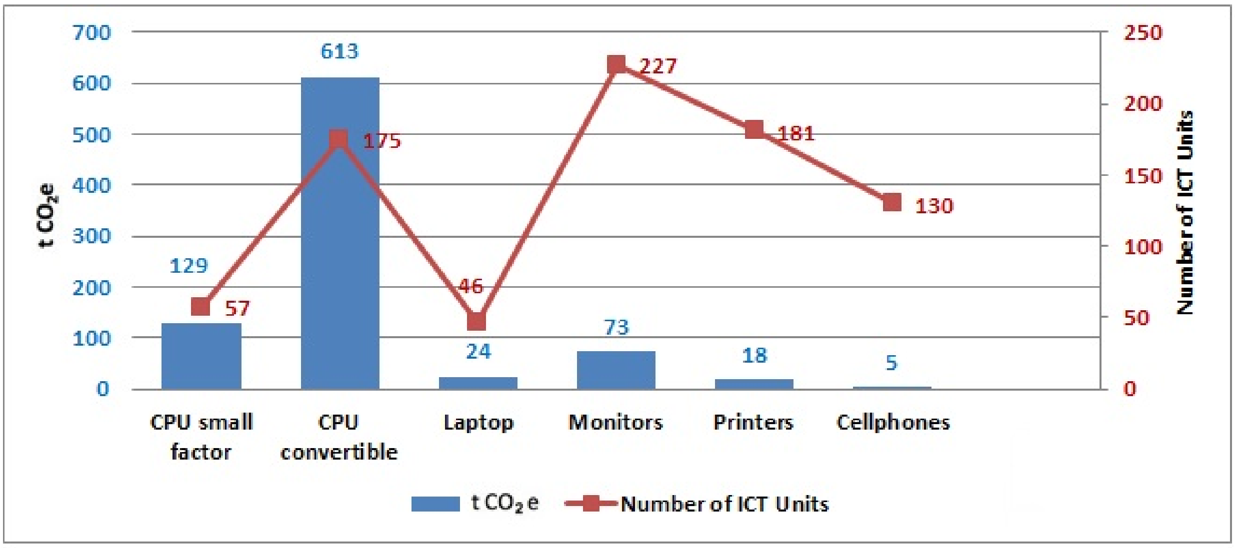


Figure 4.22 **ICT carbon variable and associated CO_2e emissions from 2010 to 2014**

Figure 4.21 shows the breakdown of ICT equipment in different years (decimal rounded). In each year, the largest CO_2e emissions were from CPU convertible, CPU small factor convertible, monitors, laptops, printers and cell phones respectively.

The ICT CO_2e emissions in 2010, 2012 and 2014 were similar because a default Eskom emission factor was used derived from averaging available emission factors.

The specific emissions of the ICT carbon variables from 2010 to 2014 are illustrated in Figure 4.22. The CPU convertible contributes considerably to CO_2e emission for ICT equipment by emitting 613 t CO_2e. The higher CO_2e emissions of the convertible CPU may be attributed to high power consumption rates used by the equipment. CPU small factor emitted 129 t CO_2e, while monitors and laptops produced 74 t CO_2e and 23 t CO_2e respectively.

Printers were responsible for about 18t CO_2e emissions. This calculation was based only on standby mode and thus the emissions during operational (printing activities) were not considered because of the unknown durations of printing. The lowest emissions were from cell phones producing 5 t CO_2e. This may be the result of lower power consumption demands on the equipment.

The daily use of ICT equipment results in energy consumption, therefore, the carbon emissions associated with the use of ICT equipment depends on the power consumption rate of that particular equipment. Table 4.12 shows power consumption of various ICT equipment and their associated carbon emissions for the period January 2010 to December 2014. There is a relationship between power consumption and carbon emissions i.e. more energy consumption results in higher carbon emissions.

Table 4.12 **Power consumptions and associated carbon emissions of ICT variables from January 2010 to December 2014**

ICT variables	**t CO_2e**	**Power consumption (kWh)**	**Number of equipment**
CPU convertible	613	583771	175
CPU small factor	129	123074	57
Monitor	73	69485	227
Laptop	24	23311	46
Printer	18	17146	181
Cell phone	5	4532	130
Total	**862**	**821319**	**816**

It is essential for Ekurhuleni Health District and provincial clinics to implement measures to reduce the power consumption of ICT equipment by procuring ICT equipment which are more energy efficient.

In addition, there is also an opportunity to reduce the ICT carbon emissions by providing employees with laptops instead of desktop computers (consisting of monitors and CPU), which increases the power consumptions and thus the carbon emissions. CPU convertible accounts for 71% of the emissions, followed by CPU small factor (15%), monitors (8%), laptops (3%), printers (2%), and cell phones (1%) (Figure 4.23). Any mitigation measures to lower ICT equipment emissions should consider the power wattage of the equipment in question.

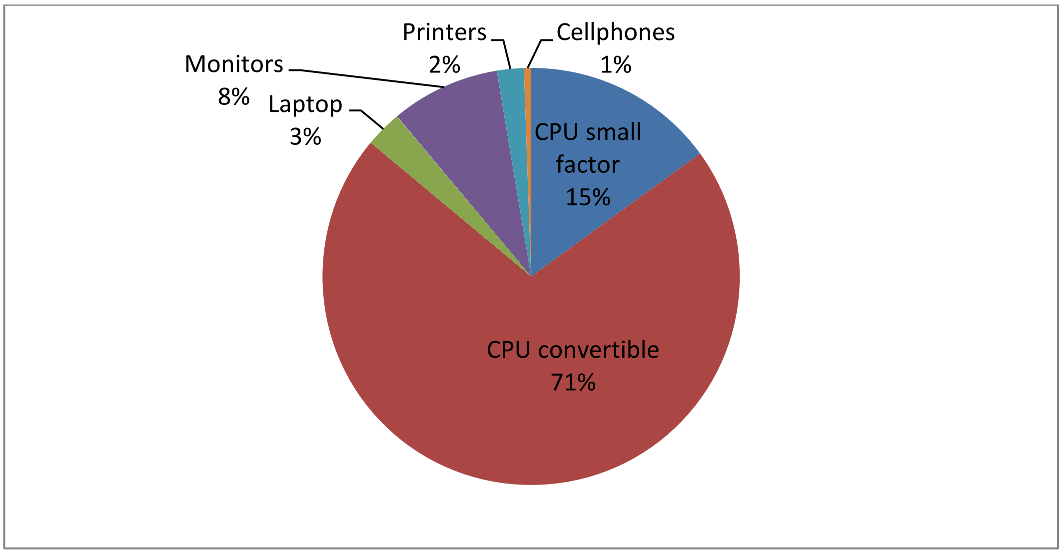


Figure 4.23 **CO_2e emission percentage for ICT equipment from 2010 to 2014**

4.5 SCOPE 3: CARBON EMISSIONS OF AIR CONDITIONERS

As discussed in Chapter 3 (3.6.5), the air conditioner information was only available at five facilities, where four were provincial clinics and one District Office. Therefore, in order to quantify the carbon footprints of the air conditioners in the district and provincial clinics, it was necessary to extrapolate for the eight (8) missing provincial clinics. This was done by averaging the available number of air conditioners in the four provincial clinics (excluding the District Office because it is an administration office) and using this average number of air conditioners to calculate the carbon footprints of air conditioners. It was assumed that the types of the missing numbers of air conditioner refrigerants are likely to be HCF-23.

Air conditioner carbon footprints were determined by GHG Protocol Methodology for refrigeration and air conditioners (GHGP, 2012c). Figure 4.24 shows the carbon footprints of air conditioners annually. The number of air conditioners in the District Office was the highest had 88 air conditioners with an emission of 30.89 t CO_2e annually. The higher

CO_2e emissions in the District Office may be attributed to the higher number of air conditioners and the type of air conditioners (HFC-23) used, which has a Global Warming Potential (GWP) of 11700.

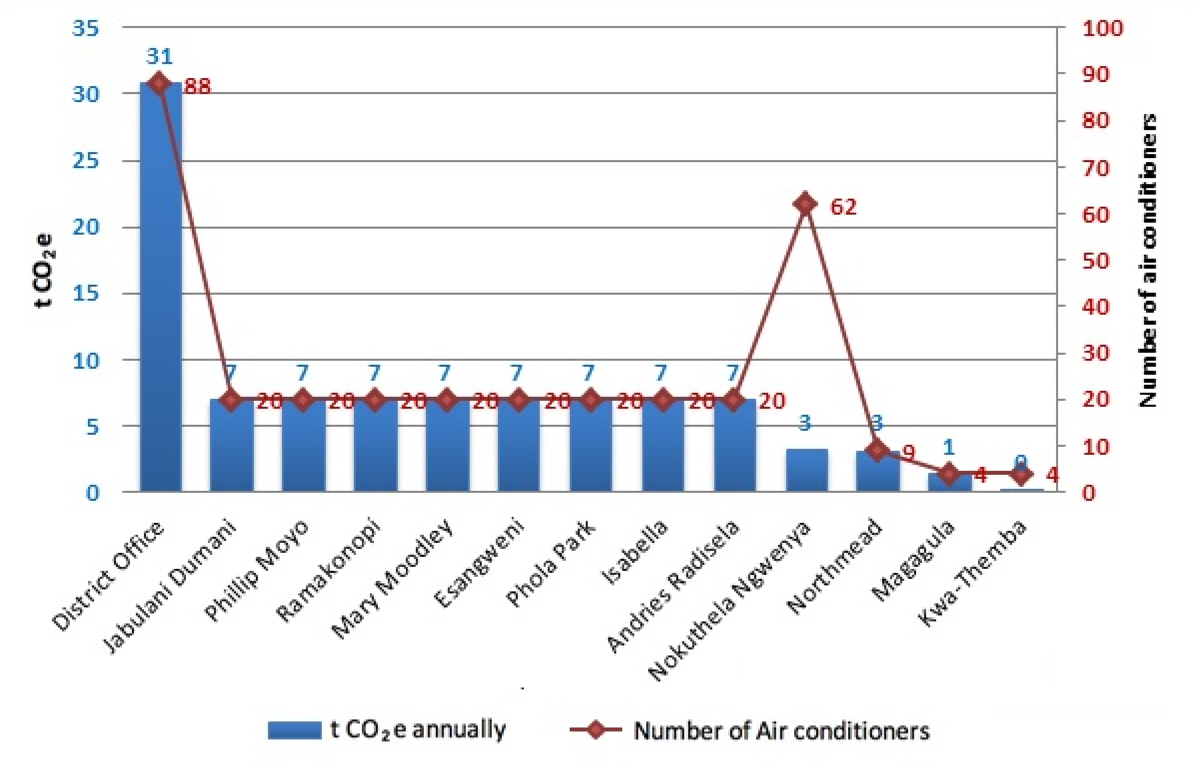


Figure 4.24 **Annual CO_2e emissions associated with air conditioners at different facilities**

The extrapolated facilities had 20 air conditioners each and emitted 7.02 t CO_2e annually per facility (Figure 4.24). These facilities include Ramakonopi, Philip Moyo, Andries Radisela, Mary Moodley, Esangweni, Phola Park, Isabella and Jabulani Dumani. Similar CO_2e emissions in these facilities may be attributed to the average number of air conditioners used to calculate the CO_2e emission due to data limitation. Nokuthela Ngwenya (62 air conditioners) and Northmead (9 air conditioners) emitted 3.21 and 3.16 t CO_2e respectively. Nokuthela Ngwenya had 62 air conditioners and produced only 3.21 t CO_2e annually, this may be attributed to the facility having R410A type air conditioners refrigerant, which has a lower Global Warming Potential (GWP) of 1725.

All the other facilities (excluding Kwa-Themba) had HFC-23 air conditioner refrigerant types, which had a GWP of 117000. The lowest annual emission was from Magagula (4 air conditioners) and Kwa-Themba (4 air conditioners) emitting 1.40 and 0.21 t CO_2e emission per year respectively.

The carbon footprints of air conditioners over the reporting period in this study (January 2010 to December 2014) is presented in Table 4.13. The CO_2e emissions associated with air conditioners for the period of five years was 475 t CO_2e. This was calculated by multiplying the annual CO_2e emissions for each facility by five years.

Table 4.13 **CO_2e emissions of air conditioners from January 2010 to December 2014**

Facilities	**Number of air conditioners**	**t CO_2e 5 years**	**Average t CO_2e 5 years**
District Office	88	154.44	1.76
Jabulani Dumani	20	35.10	1.76
Phillip Moyo	20	35.10	1.76
Ramakonopi	20	35.10	1.76
Mary Moodley	20	35.10	1.76
Esangweni	20	35.10	1.76
Phola Park	20	35.10	1.76
Isabella	20	35.10	1.76
Andries Radisela	20	35.10	1.76
Nokuthela Ngwenya	62	16.04	0.26
Northmead	9	15.80	1.76
Magagula	4	7.02	1.76
Kwa-Themba	4	1.04	0.26
Grand Total	**327**	**475.00**	**20.00**

Once again, the highest CO_2e emissions associated with air conditioners was from the District Office (154.44 t CO_2e). The higher CO_2e emissions may be ascribed to the larger number of air conditioners and types of air conditioners (HFC-23). The extrapolated facilities (Ramakonopi, Philip Moyo, Andries Radisela, Mary Moodley, Esangweni, Phola Park, Isabella and Jabulani Dumani) emitted 35.1 t CO_2e individually and had 20 air conditioners each. The similar CO_2e emissions and number of air conditioners in these facilities maybe be attributed to an average number of air conditioners used to calculate the CO_2e emission due to lack of data.

Nokuthela Ngwenya (62 air conditioners) and Northmead (9 air conditioners) (Table 4.13), emitted 16.04 and 15.80 t CO_2e respectively. In the case of Nokuthela Ngwenya, the lower t CO_2e emission may be attributed to the facility having R410A type air conditioners refrigerant which has a lower global warming potential (GWP). All the other facilities (excluding Kwa-Themba) had HFC-23 air conditioner refrigerant types which had a higher global warming potential (GWP) . The lowest emissions were from Kwa- Themba (4 air conditioners) and Magagula (4 air conditioners) emitting 1.04 and 7.02 t CO_2e emission per year respectively. Furthermore, the most efficient facilities in terms of average t CO_2e emissions (t CO_2e/ number of air conditioners) was Nokuthela Ngwenya and Kwa-Themba facilities, which may be attributed to the air conditioner refrigerant type (R410A) used.

4.6 SUMMARY OF DISCUSSION

4.6.1 Total carbon footprint of Ekurhuleni Health District and provincial clinic employees (2010-2014)

As discussed in Chapter 3, different carbon variable information, such as government fleet vehicles, office paper consumed, ICT equipment, air conditioners and electricity consumed were collected and analysed for their CO_2e emissions. A total of 38030 t CO_2e emissions were directly and indirectly released into the atmosphere. Table 4.14 summarises the total carbon footprints of Ekurhuleni Health District Office and Provincial Clinics per scope and the influence of double counting from January 2010 to December 2014. In order to explain the possible influence of double counting (ICT equipment) in the total carbon footprint emissions, it was necessary to present two grand totals, one comprising double counting (38030) and other excluding double counting (37168) emissions. The contribution of ICT emission accounts for approximately 2% (862/38030*100) of the total emissions and henceforth is included in the discussion and presentation of the results.

Table 4.14 **Total carbon footprints of Ekurhuleni Health District Office and provincial clinics per scope and the influence of double counting from January 2010 to December 2014**

Carbon variables	t CO_2e (total)	t CO_2e (total excluding double counting)
Vehicles (Scope 1)	1362	1362
Electricity (Scope 2)	35150	35150
ICT (Scope 3)	862	N/A*
Air Conditioner (Scope 3)	475	475
Office Papers (Scope 3)	181	181
Grand total	**38030**	**37168**

* N/A = not applicable, ICT equipment emissions for double counting is excluded.

In this study, Scope 1 emission consist of direct emissions from government fleet vehicles, while Scope 2 emissions are associated with the electricity consumption and Scope 3 emissions include indirect emissions from office paper use, ICT and air conditioners.

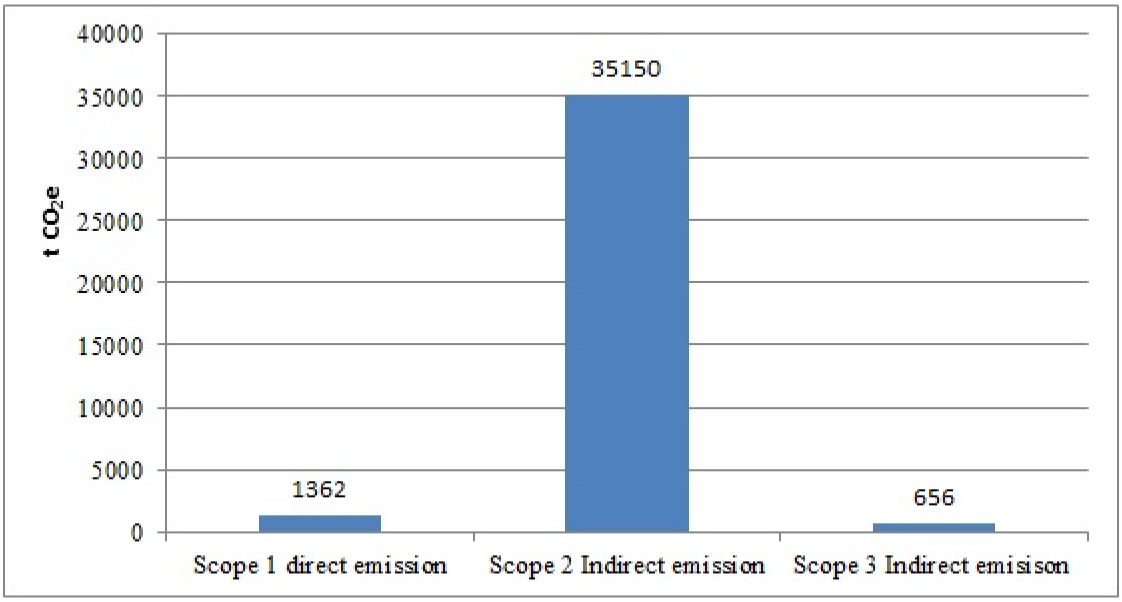


Figure 4.25 **Scope 1, 2 and 3 carbon emissions from January 2010 to December 2014**

Figure 4.25 shows the emissions associated with Scope 1, 2 and 3 from January 2010 to December 2014. The total carbon footprint of Ekurhuleni Health District and provincial clinics employees, based on carbon emissions from January 2010 to December 2014, is presented using two scenarios. The first scenario includes Scope 1, 2 and 3 as presented in Figure 4.26. The highest CO_2 emission was from electricity 35150 t CO_2e (92%), followed by vehicles emitting 1362 t CO_2e (4%), ICT 862 t CO_2e (2%), air conditioners 475 t CO_2e (1%) and office paper 181 t CO_2e (1%).

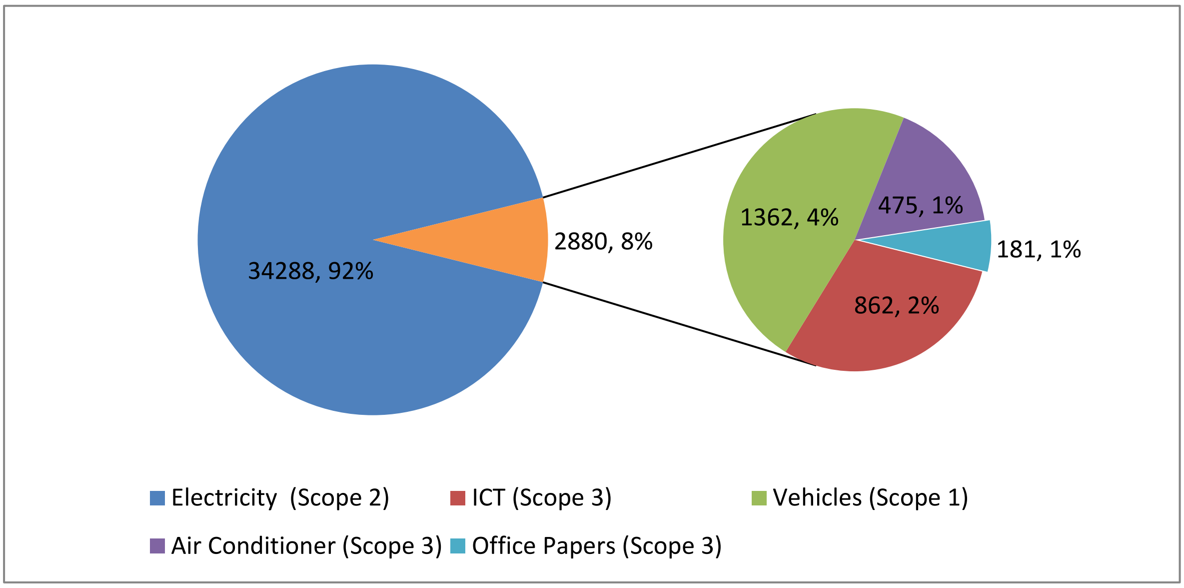


Figure 4.26 **Scenario One: Total carbon footprint of Ekurhuleni Health District and provincial clinic employees from January 2010 to December 2014 (Scope 1. 2 & 3)**

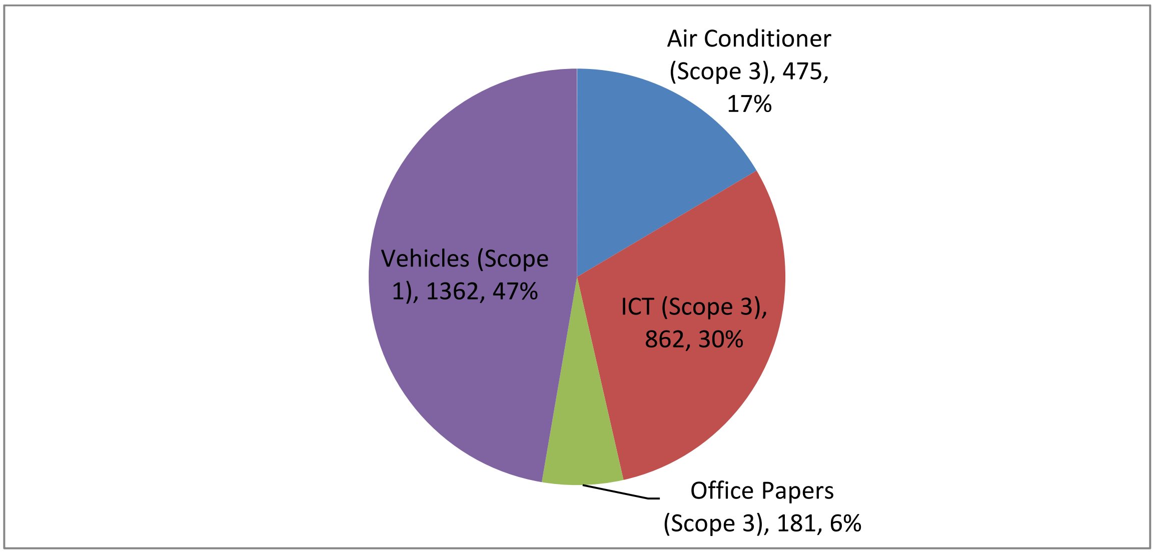


Figure 4.27 **Scenario Two: Total carbon footprint of Ekurhuleni Health District and provincial clinic employees from January 2010 to December 2014 (Scope 1 & 3) excluding electricity**

Figure 4.27 shows Scenario Two (Scope 1 & 3) of the total carbon footprint of Ekurhuleni Health District and provincial clinic employees from January 2010 to December 2014. Government vehicles had the highest emissions of 1363 t CO_2e (47%), followed by ICT 862 t CO_2e (30%), air conditioners 475 t CO_2e (17%) and office papers 181 t CO_2e (6%).

Scenario Two excluded Scope 2 emissions associated with electricity due to data limitation of ten 10 facilities in which an average kilowatts derived from two provincial clinics was used to calculate their carbon footprints.

4.6.2 Summary of discussion of Scope 1 (vehicles) emissions

4.6.2.1 Emission trends

The carbon footprint of vehicles contributes 4% (1362 t CO_{2e}) of the total carbon footprint of Ekurhuleni Health District from 2010 to 2014. There was a relationship between increased fuel consumption and increased carbon emissions by the vehicles. The highest carbon emissions occurred in 2011 producing 328 t CO_2e and the least in 2013 emitting 222 t CO_2e. This was contributing to the increase number of average available vehicles (116) in 2011 and the decrease of vehicles (69) in 2013, due to the service provider re-calling vehicles because of non-payment by the District Office. In terms of vehicle activities days, the highest vehicle usage days (21297) occurred in 2011 and the least occurred in 2013 (13508 days), because of the increase and decrease in the average number of vehicles available to render health services respectively.

Visual monthly CO_2e emission trends was noted showing a decrease in the carbon emission in December months, which may be as a result of employees going on leave in December. A gradual increase in the CO_2e emissions noted in January to March in most years may be ascribed to employees coming back to work from leave.

4.6.2.2 Comparison of CO_2e emissions with fuel, engine size and manufacturer

The DEFRA methodology and vehicle manufacturers enable the calculation of vehicle carbon emissions based on the information on fuel use, vehicle engine size and the vehicle specific emission factors of the manufacturers. The study compared the vehicles carbon footprint based on the above information. There was little difference between the carbon emissions of fuel and engine size. This may be due to the engine size values being used as a default value for the calculation of carbon emissions by the manufacturer and the unavailability of emission factors. There was a considerable difference in carbon emission of fuel and other calculated carbon emissions variables i.e. engine size and manufacturer, because of the fuel emission factors being higher than engine size emission factors.

Ekurhuleni Health District makes use of petrol and diesel vehicles in rendering health services to the communities. A comparison between the GHG emissions of petrol and diesel vehicles were made. The results showed that diesel vehicle carbon emissions were lower than the petrol vehicles because of the lower number of diesel vehicles.

4.6.2.3 Comparison of WRI GHG Protocol and DEFRA methodology

Monthly comparison of petrol and diesel vehicle CO_2e emission between WRI GHGP and DEFRA methodology from January 2010 to December 2015 showed little differences. This suggests that the WRI GHGP and the DEFRA methodologies have similar emission factors. However, monthly diesel CO_2e emissions, showed a slight visual correlation, which may be attributed to an average fuel CO_2e emissions used due to lack of data (see section 4.1.7).

4.6.2.4 Vehicle manufacturer CO_2e emissions and efficiency

Volkswagen vehicles present 40% of the total number of vehicles and contributed to the highest carbon emission of 518 t CO_2e from January 2010 to December 2014, followed by Nissan which accounted for 19% of the total vehicles and emitted the second highest carbon emission of 272 t CO_2e. The higher emission from Volkswagen and Nissan are due to the higher number of these vehicles in the vehicle fleet. The third highest emitter was Iveco releasing 130 t CO_2e. Even though it makes up only 4% of the total number of vehicles, they use diesel fuel which has a higher emission factor than petrol and has a larger engine capacity. Toyota, Opel and Isuzu produced 95, 93 and 55 t CO_2e emissions and make up 8.5%, 9% and 3% respectively.

The least carbon efficient vehicles in terms of average CO_2e emissions (CO_2e divided by the number of vehicles) were Iveco with Mercedes and Isuzu tied in the second and third place respectively. These vehicles have larger engine capacities and uses diesel fuel that has a higher emission factor than petrol.

4.6.2.5 Volkswagen and Nissan model CO_2e emissions and efficiency

Volkswagen models with the highest CO_2e emissions from January 2010 to December 2014 were the Polo 1.4 Trendline H/B emitting 132 t CO_2e; the Polo Vivo 1.4 releasing 76 t CO_2e; the Polo Classic 1.4 Trendline with 74 t CO_2e emissions; the Polo 1.6 Trendline producing 62 t CO_2e; and Citi Golf 1.4 discharging 54 t CO_2e. The combined CO_2e emission for the other models was 122 t CO_2e and accounts for 18% of the models. The most carbon efficient Volkswagen models were Polo Vivo 1.4 Concept 5DR, Citi Golf 1.4 and Polo 1.6 Trendline and Caddy 2.0 TDI P/V.

Nissan models with the highest CO_2e from January 2010 to December 2014 were: Nissan Hardbody 2.4 Hi-Rider (118 t CO_2e); followed by Nissan Hardbody 2.4i Scab LWB (33t CO_2e); the Tida 1.6 Visia (30 t CO_2e); the Primastar 1.9 DCL 9-Seater and the Micra 1.4 that emitted 29 and 28 t CO_2e respectively. While Livina 1.6 Acenta (H84) produced 26 t CO_2, the rest of the models accounted for 4% of the vehicles and produced 7t CO_2e. The most efficient Nissan models in terms of averaged CO_2e (CO_2e emissions divided by the number of vehicles) were Micra 1.4, Nissan 1400 LDV and Livina 1.6 Acenta (H84).

4.6.3 Summary of the discussion of Scope 2 emissions

Electricity carbon footprint in Ekurhuleni Health District accounts for 92% (35150 t CO_2e) of the total emissions from January 2010 to December. The total CO_2e emissions from electricity sold and electricity generated from January 2010 to December 2014 were 35150 t CO_2e and 33474 t CO_2e respectively. In this study reference is made to the sold CO_2e emissions.

The highest CO_2e emissions was from the District Office (4117 t CO_2e), followed by Nokuthela Ngwenya (3885 t CO_2e) and the lowest CO_2e emissions was from Northmead (344 t CO_2e). The CO_2e emissions of the remaining extrapolated facilities were constant at 2680 t CO_2e, which is attributed to an average kilowatts of electricity consumption used to calculate the CO_2e emissions due to lack of data.

4.6.4 Summary of the discussion of Scope 3 (paper, ICT, air conditioners) emissions

4.6.4.1 Carbon footprint of printing paper

Office paper carbon footprint in Ekurhuleni Health District accounts for 1% (181 t CO_2e) of the total emissions from January 2010 to December 2014. The highest carbon emission occurred in 2014 producing 43 t CO_2e and the least in 2012 emitting 27 t CO_2e. The study indicates possible carbon emissions trends showing a slight increase in the carbon emissions in the first two month in most quarters. The increased activity usage may be attributed to producing reports or other administration activities to meet quarterly targets, no doubt played a role.

A comparison was made between Sappie and Mondi paper manufacturers in terms of carbon emissions. The study highlights that when the emission factor excluding electricity was used, there was a difference of 12 t CO_2e between the two paper manufactures. The carbon emission (157t CO_2e) of Mondi was lower than that of Sappie (169 t CO_2e). However, when the emission factor including electricity was used, the carbon emissions of Mondi were 43% higher than Sappie, showing a difference of 243 t CO_2e. This shows the importance to the paper industry to investigate and implement production energy use carbon emission reduction measures.

4.6.4.2 Carbon footprint of information and communication technology (ICT)

ICT equipment accounts for 2% (862 t CO_2e) of the total carbon footprints in Ekurhuleni Health District office. The carbon emissions associated with ICT equipment are associated with the consumption of power. There was a visual relationship between higher power usage and the increase in carbon emissions. The highest carbon emissions occurred from CPU convertible and accounts for 71% of the emissions, followed by CPU small factor (15%), monitors (8%), laptops (3%), printers (2%) and cell phones (1%). The lower carbon emissions associated with cell phones may be attributed to the lower power consumption rate of the equipment. The carbon emission calculations for printers were based on standby mode only and the emissions during operational (printing activities) were not considered because of the unknown times of printing and the duration. Considering that ICT equipment contributed to 2% of the total carbon footprint in Ekurhuleni Health District, measures need to be implemented to reduce the emissions. The study identified possible emission reduction strategies for ICT equipment, such as procuring energy efficient equipment and substituting desktop computers with laptops.

4.6.4.3 Carbon footprint of air conditioners

Air conditioners contributed to 1% (458 t CO_2e) of the total carbon footprint of Ekurhuleni Health District from January 2010 to December 2014. The highest CO_2e emissions associated with air conditioners was from the District Office (154.44 t CO2e). The higher CO_2e emissions may be ascribed to the larger number of air conditioners and types of air conditioners (HFC-23) used.

Nokuthela Ngwenya and Northmead clinic emitted 16.04 and 15.80 t CO_2e respectively. In the case of Nokuthela Ngwenya, the lower t CO_2e emission may be attributed to the facility having R410A type air conditioners refrigerant which has a lower global warming potential (GWP).

The extrapolated facilities (Ramakonopi, Philip Moyo, Andries Radisela, Mary Moodley, Esangweni, Phola Park, Isabella and Jabulani Dumani) emitted 35.1 t CO_2e individually and had 20 air conditioners each. The similar CO_2e emissions and number of air conditioners in these facilities maybe be attributed to an average number of air conditioners used to calculate the CO_2e emission due to lack of data.

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Chapter 5
RESULTS AND DISCUSSION OF PERCEPTION OF CLIMATE CHANGE

The second research objective of the study was to determine the knowledge and perceptions of climate change among managers and operational employees in Ekurhuleni Health District and provincial clinics. In order to achieve this objective, 33 face-to-face interviews were conducted. The interview responses were tape recorded and transcribed into Microsoft Word. The various responses were coded into similar categories. Content analysis was used to formulate keywords, noting the frequency and the emerging themes were identified.

Purposive sampling method was used to select the research participants, in order to obtain a balanced view of the perception of climate change of the different management hierarchy within Ekurhuleni Health District Office and Provincial Clinic. The interviews were conducted with top management, middle management and employees at the operational level. However, due to a lower response rate in the top management (only two participants), top management and middle management were combined to form a similar management group. This chapter commences with the profiles of the research participants. Nine questions were presented of which four focused on knowledge and the remaining five questions assessed perceptions. The responses are presented in frequency tables and the emerging themes are discussed. The figures and tables presented in this chapter were rounded to a decimal place.

5.1 PROFILE OF PARTICIPANTS

A total of 33 research participants were interviewed of which 30% (n=10) were at management level and 70% (n=23) were operational employees as shown in Figure 5.1. Management consisted of two deputy directors and eight assistant directors of whom six were professional nurses, one an environmental health practitioner, one a dietician (nutrition), one an administrator and one a finance practitioner (Figure 5.2). The managers (deputy and assistant directors) managed different units within Ekurhuleni Health District. Eight (8) managers were based at the District Office, one at Nokuthela Ngwenya Clinic and one at the Kwa-Temba Clinic (Figure 5.3).

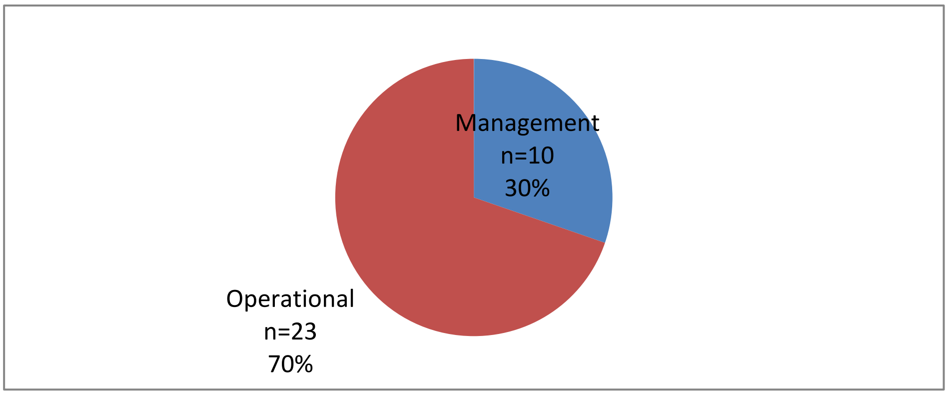

Figure 5.1 **Total number and category of employees interviewed**

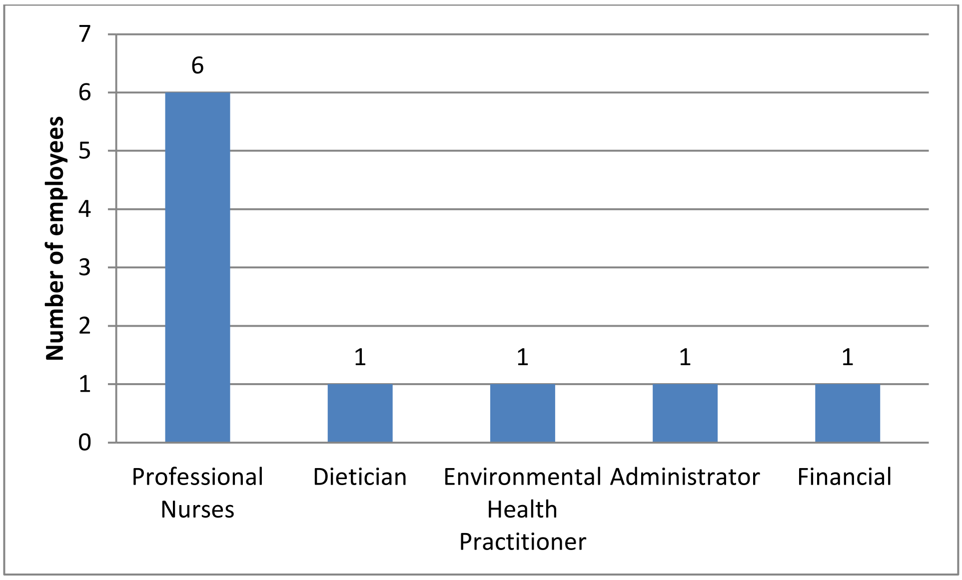

Figure 5.2 **Occupations of managers and number interviewed**

Figure 5.3 **Facilities where managers interviewed were stationed**

A total of twenty three (23) employees were interviewed in the operational level category. The interviewed employees had different designated titles. Most participants were administrators (7), followed by nurses (5), environmental health practitioners (3) and two participants were from Human Immunodeficiency Virus (HIV) counselling and testing. The other six participants had various designated titles, as indicated in Figure 5.4.

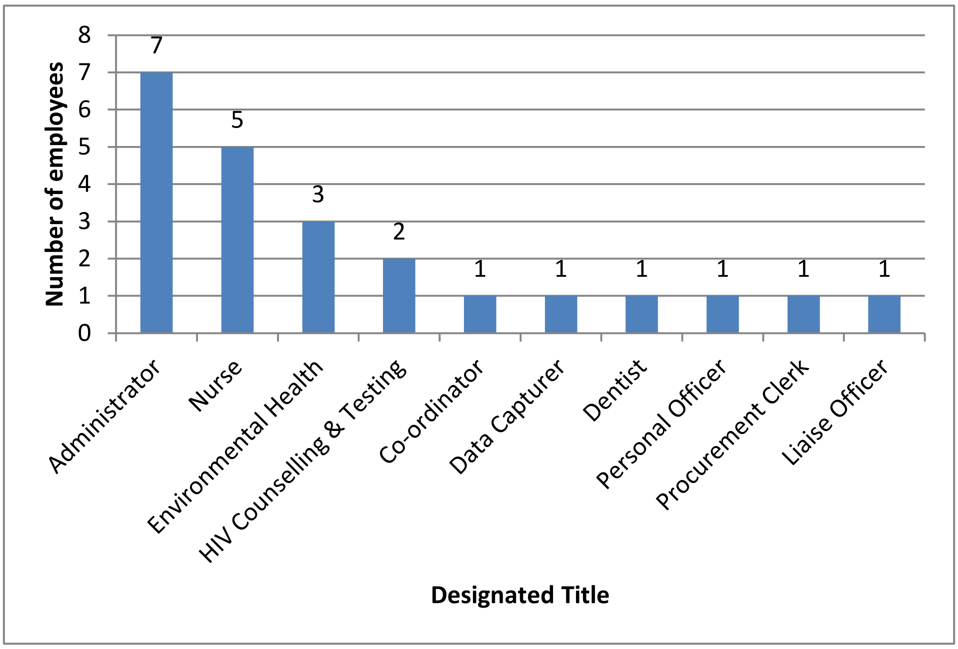

Figure 5.4 **Operational level employees designated titles and number of interviews conducted**

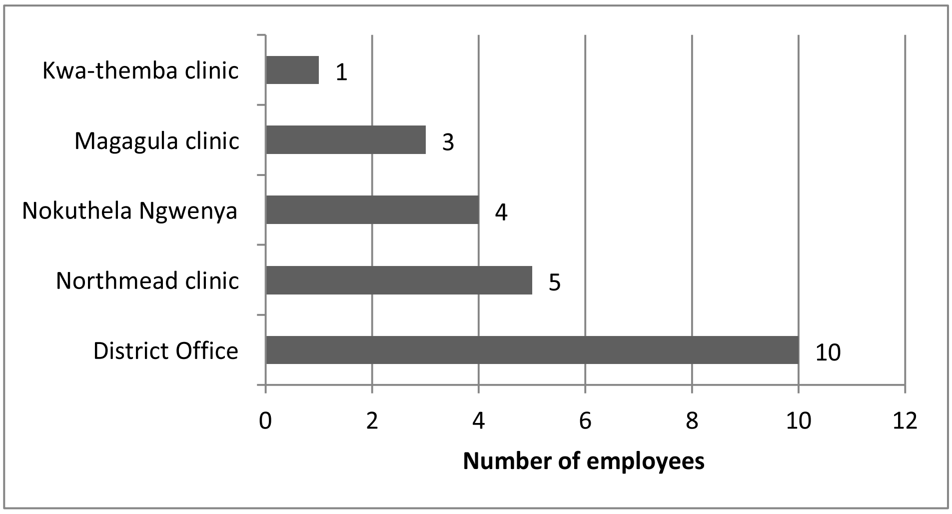

Figure 5.5 **Facilities and number of operational employees interviewed**

The District Office had the greatest number of participants (10), followed by Northmead Clinic (5), Nokutela Ngwenya Clinic (4), Magagula Clinic (3) and Kwa-Temba (1) (Figure 5.5).

5.2 UNDERSTANDING OF CLIMATE CHANGE

The research participants were asked what they understand about climate change. The responses of the managers to the question were all correct and showed a basic understanding of climate change. Table 5.1 provides the keyword frequency count. The understanding of climate change by management was mainly related to "changes in the weather/climate/season" (26%). Their views may be attributed to their personal observation of weather changes. The keyword frequency of "too hot" and "ozone layer" were 16% and 11% respectively.

Table 5.1 **Management: Keyword frequency for understanding climate change**

Keywords	Frequency	%
Changes in weather/climate/season	5	26%
Too hot	3	16%
Ozone Layer	2	11%
Destroying animals	1	5%
Rain	1	5%
Destroying plants	1	5%
Melting ice	1	5%
Destroying water	1	5%
Too cold	1	5%
Damages lungs	1	5%
Heat waves	1	5%
Greenhouse gases	1	5%
Total	**19**	**100%**

The response rate from the operational employees, regarding their understanding of climate change, is presented in Figure 5.6. The majority of the employees (87%) had a basic understanding of climate change, while 9% provided incorrect answers and 4% indicated that they "do not know". The following are examples of the responses of the 9% of the operational employees with incorrect answers.

> *"It is the destruction of the climate by different forces, like pollution."*
>
> *"It's more like geographical changes in conditions regarding the weather, oxygen and everything related to weather and climate."*

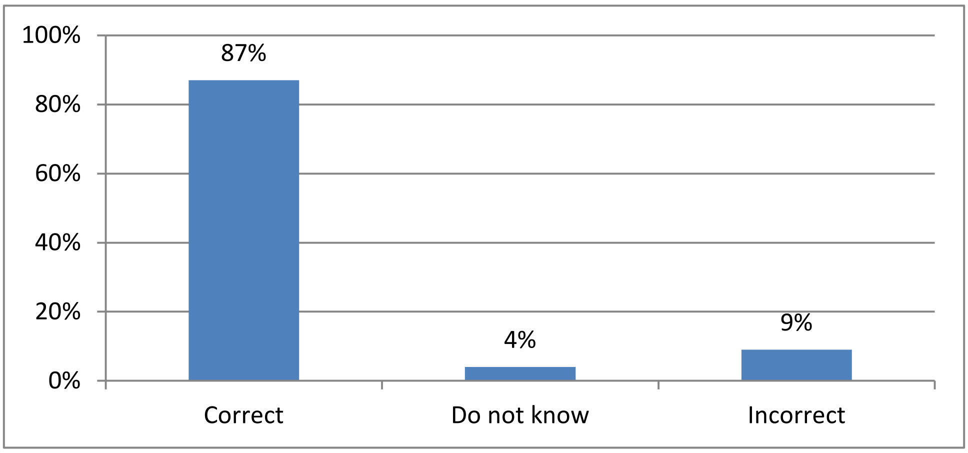

Figure 5.6 **Operational employees: Understanding of climate change**

Table 5.2 presents the keyword frequency count of the responses of the operational employees on their understanding of climate change. “Changes in weather/season/climate” had the highest frequency (28%) followed by “too hot” (15%), “too cold” (11%), “greenhouse gases” (11%) and the remaining responses (7%, 4% and 2%) as shown in the table.

Table 5.2 **Operational employees: Keyword frequency of understanding of climate change**

Keywords	Frequency	%
Changes in weather/season/climate	13	28%
Too hot	7	15%
Too cold	5	11%
Greenhouse gases	5	11%
Ozone layer	3	7%
Raining	3	7%
Pollution	2	4%
Wind	1	2%
Global warming	1	2%
Melting ice	1	2%
Industries	1	2%
Volcano	1	2%
Sickness	1	2%
Cars	1	2%
Storms	1	2%
Grand total	**46**	**100%**

The two highest frequencies were “changes in weather/season/climate” and “too hot” which accounts for 28% and 15% respectively. These were followed by “too cold” and “greenhouse gases” at 11%. “Ozone layer” and “raining” accounts for 7%. The top two keywords for the managers and the operational employees were similar, suggesting a possible theme of ‘climatologic changes’.

5.2.1 Theme 1: Climatologic changes

The understanding of climate change for both management and operational level employees were linked to observational changes in climate due to sudden weather changes. One participant’s response to the understanding of climate change was *“how the climate is now, compared to the way it was back in the days, and how the climate had changed”*. A similar response from a participant regarding unfamiliar seasonal changes due to climate change was noted “*things are not happening as we know as far as the season is concerned … because of climate change the seasons are doing miracles”*. A research participant mentioned the unpredictability of the weather “*we do not understand the rain and weather in general”*.

An increase of temperature was also a concern by the research participants. One employee believed that the earth is getting warmer “*The environment and the earth is hotter than before*”. One participant also highlighted that the weather nowadays is either too hot or too cold, which is attributed to abnormal changes of the weather, *“Its abnormal changes in the weather i.e. too cold or too hot”*. One employee linked the increasing temperature to the emission of carbon dioxide saying, “*The changes in the temperature is becoming extremely high due to a lot of carbon dioxide”*.

The following question was posed to the employees: In your opinion, what do you think causes climate change? Most (70%) managers had a basic understanding of the causes of climate change, while 10% of the managers indicated “do not know” and 20% of the managers had an incorrect understanding of climate change (Figure 5.7).

Examples of the comments of the 20% incorrect responses by the managers are provided below:

> *“Environmental factors and other factors”*
>
> *“…globalization, which involves taking plants from other areas into South Africa. Therefore, South African weather needs to change to honour those kinds of plants. Other things, such as lead poisoning and environmental sources should be considered.”*

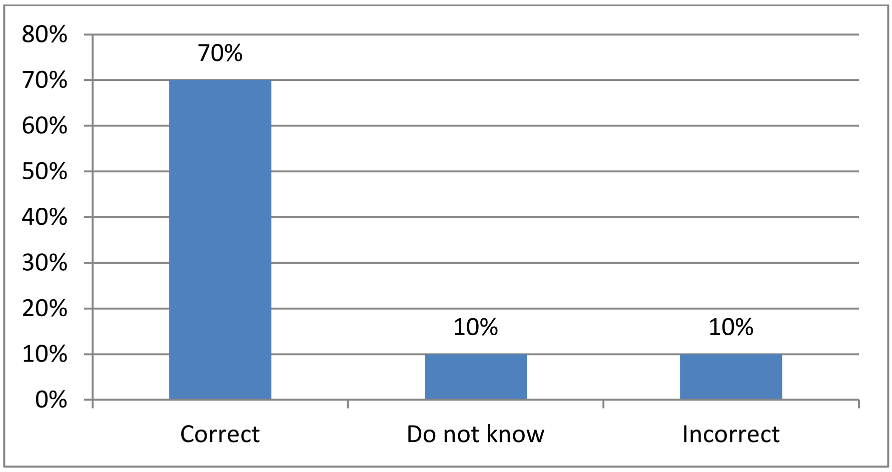

Figure 5.7 **Managers: Responses to causes of climate change**

Some managers (33%) believed that greenhouse gases were the main causative agent of climate, followed by pollution and vehicles (19%), industries (14%). burning of substances (10%) and deforestation (5%) (Table 5.3).

Table 5.3 **Managers: Keyword frequency of causes of climate change**

Keywords	**Frequency**	**%**
Greenhouse gases	7	33%
Pollution	4	19%
Vehicles	4	19%
Industries	3	14%
Burning	2	10%
Deforestation	1	5%
Total	**21**	**100%**

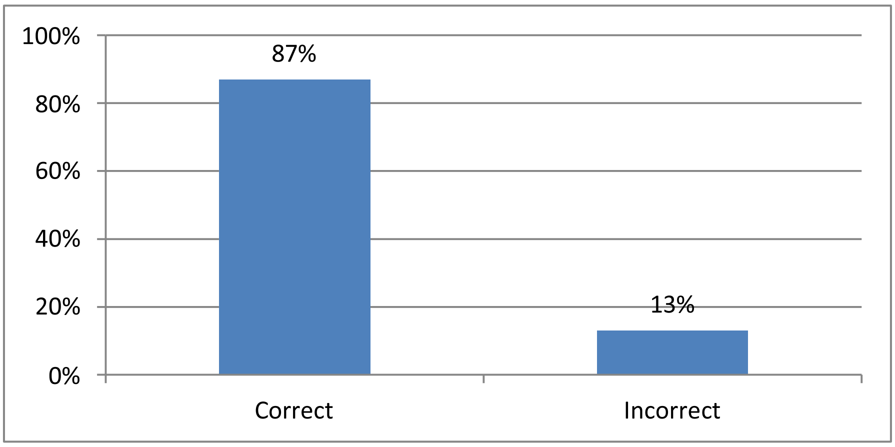

Figure 5.8 **Operational employees: Responses to the causes of climate change**

Of the operational employees, 87% had a basic understanding of the causes of climate change, while 13% of the operational employees gave incorrect answers (Figure 5.8). Some comments are provided here.

> *"It is natural"*;
>
> *"Overcrowding when we are too crowded is what comes to mind. Breathing out CO_2, which goes up, condenses and forms clouds and it rains..."*

According to the keyword frequency regarding the causes of climate change, the responses of the operational employees revealed the following three top causes, namely greenhouse gases (30%), pollution (14%) and industries and vehicles (11%) (Table 5.4). This result concurs with the responses of the managers suggesting a possible theme of 'human induced climate change'.

Table 5.4 **Operational employees: Keyword frequency of causes of climate change**

Keywords	**Frequency**	**%**
Greenhouse gases	19	30%
Pollution	9	14%
Industries	7	11%
Vehicles	7	11%
Burning	6	10%
Ozone layer	5	8%
Deforestation	4	6%
Humans	4	6%
Animals	2	3%
Total	**63**	**100%**

5.2.2 Theme 2: Human induced climate change

The research participants highlighted the day-to-day activates of people as the main causative agent of climate change. A participant indicated that "*carbon dioxide and carbon monoxide are responsible for making a hole in the ozone layer*". This statement endorses the detrimental effects of greenhouse gases on the ozone layer, which in the long-term cause climate change. The depletion of the ozone layer due to greenhouse gases was also highlighted by one participant, "*it's all the gases that are released into the air that affect the outer layer of the earth*".

Pollution, from burning of coal and other substances was also stressed by the participants *"it's caused by human beings themselves with all the burning they do"*. In addition, a participant indicated that it was *"mostly caused by human activities such as vehicles emitting gases and burning of substances"*. The employees also mentioned vehicles and industries as the main causes of climate change *"there are many causes, such as number of cars which are polluting the air with gases and companies which play a part in pollution"*. One employee stated that driving itself contributes to climate change *"driving of vehicles produces carbon dioxide"*.

5.3 CONSEQUENCES OF CLIMATE CHANGE

The question asked in this section was: "In your opinion, what are the consequences of climate change in general?" The keywords and frequencies for managers and operational employees are presented in Table 5.5 and Table 5.6 respectively. Some keywords can be grouped together further highlighting a specific point or consequences. For example, flooding, storms, etc. can be grouped as adverse weather and respiratory illness can affect health, as diseases or illnesses.

Table 5.5 **Managers: Keyword frequency of consequences of climate change**

Keywords	**Frequency**	**%**
Changes in season or climate	6	14%
Pollution (water & air)	4	9%
Flooding	4	9%
Affects the economy	3	7%
Increase temperature or hot	3	7%
Respiratory illnesses	3	7%
Affects plants	3	7%
Affects water	3	7%
Affects human health	2	5%
Cold	2	5%
Thunderstorms	2	5%
Ozone layer	1	2%
Animal migration	1	2%
Deforestation	1	2%
Poverty	1	2%
Heat stroke	1	2%
Drought	1	2%
Heavy rain	1	2%
Hail storm	1	2%
Grand total	**43**	**100%**

***Table 5.6* Operational employees: Keyword frequency of consequences of climate change**

Keywords	Frequency	%
Changes in weather or climate	10	16%
Increase temperature or hotter	8	13%
Heavy rain	6	10%
Diseases	5	8%
Drought	5	8%
Sickness or illness	4	6%
Poverty	4	6%
Floods	3	5%
Storms	3	5%
Affects plants	2	3%
Cold	2	3%
Malaria	2	3%
Cancer (Ultraviolet radiation)	1	2%
Tuberculosis	1	2%
Respiratory illnesses	1	2%
Melting ice	1	2%
Pollution	1	2%
Flue	1	2%
Affects animals	1	2%
Global warming	1	2%
Grand Total	**62**	**100%**

***Table 5.7* Managers: Revised keyword frequency of consequences of climate change**

Keywords	Frequency	%
Adverse weather	14	33%
Diseases or illnesses	6	14%
Changes in season/climate	6	14%
Pollution (water & air)	4	9%
Affects the economy	3	7%
Affects plants	3	7%
Affects water	3	7%
Animal migration	1	2%
Poverty	1	2%
Ozone layer	1	2%
Deforestation	1	2%
Total	**43**	**100%**

Table 5.7 shows the revised frequency table for managers regarding the consequences of climate change. Adverse weather (flooding, droughts, etc.) accounts for 33% of the total keyword frequency, while diseases or illnesses and changes in the season or climate each accounts for 14%.

The revised frequencies for the operational level employees reveals that 45% made reference to adverse weather conditions, followed by diseases/illnesses at 24% and changes in weather/climate at 16% (Table 5.8). A re-emerging theme is noted again, which was covered in the section (5.2.1), "Theme 1: Climatic changes", which employees observed of weather or seasonal changes. Possible themes in this section includes 'adverse weather conditions' and 'increase in disease rates'

Table 5.8 **Operational employees: Revised frequency table regarding consequences of climate change**

Climate change variables	**Number**	**%**
Adverse weather	28	45%
Diseases or illnesses	15	24%
Changes in weather or climate	10	16%
Poverty	4	6%
Affects plants	2	3%
Pollution	1	2%
Affects animals	1	2%
Global warming	1	2%
Total	**62**	**100%**

5.3.1 Theme 1: Adverse weather conditions

The most outlined consequences of climate change by the research participants was adverse weather conditions. For instance, an employee noticed that recently there had been an increase in heavy rainfall and thunderstorms, "*what I have seen is the thunderstorms and heavy rains*". This statement is indicative of the consequences of climate change that are already occurring. The effects of adverse weather conditions, such as droughts and increased temperature on crops and animals were also highlighted, "*droughts, hot weather and low rain causing cows and crops to die*". The impact on farmers was mentioned by one of the participants "*seeds are planted but there is no rain… cattle die because of drought*".

5.3.2 Theme 2: Increase in disease rates

Disease or illness was the second most-mentioned consequences of climate change. This may be a reflection of the health background of the employees or working in the health sector. One participant believed that climate change causes respiratory-related illnesses which complicated tuberculosis, "*chest- and lung-related health problems which complicates TB, lung cancer and chronic obstructive airways diseases are all due to climate change*". Employees were also concerned about re-emerging diseases due to climate change, "*…also we might be having diseases that had previously been eradicated re-merging*". One employee mentioned malaria as a concern due to the effect of climate change.

Some of the comments communicated concerns regarding the development and frequency of common diseases, that temperature or seasons can affect their well-being or health like the occurrence of influenza and also heat stroke due to the increased temperature.

> "*…sickness and diseases that we never saw before are becoming more common*".
>
> "*Sickness due to rapid change of weather*"
>
> "*For instance, we know it is supposed to be summer, but all of a sudden it is cold as it is in winter, therefore there are changes in the body which causes flue*".
>
> "*Heat stroke will result in absenteeism at work, which will affect the economy*".

5.4 OPINIONS ON GREENHOUSE GASES (GHGs)

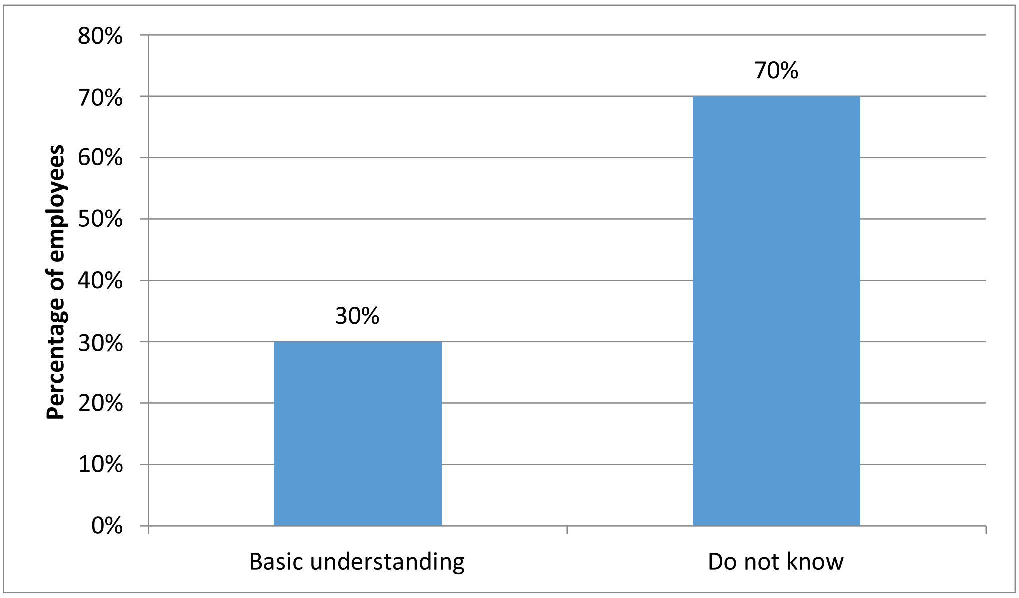

Figure 5.9 **Response of managers regarding GHGs**

Figure 5.9 shows the response from managers regarding greenhouse gases. Of the managers 70% did not know what greenhouse gases were and 30% only had a basic understanding of climate change. In the case of the majority of the operational employees, 52% did not know about GHGs, while some (17%) had misconceptions about the term “greenhouse gases” with only 30% of the employees having a basic understanding of GHGs as shown in Figure 5.10.

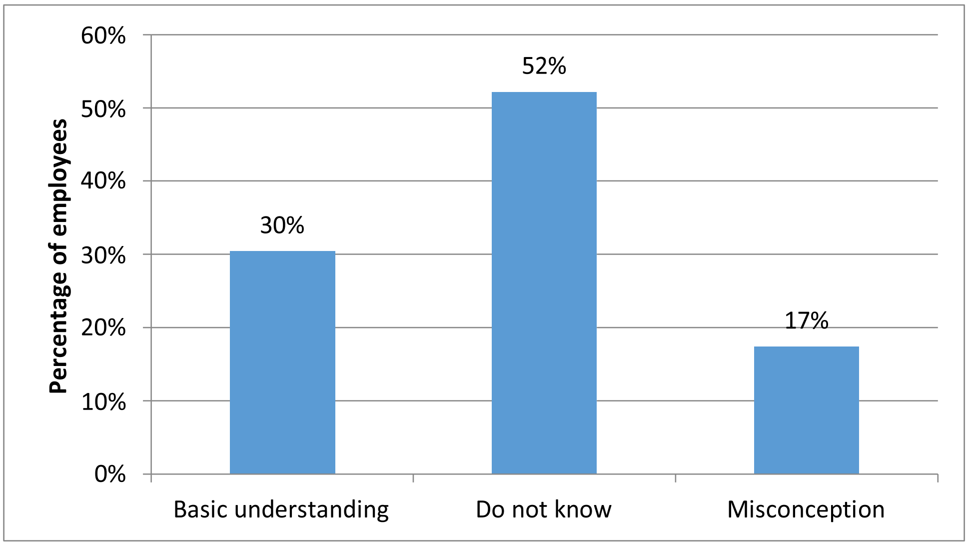

Figure 5.10 **Operational employees: Understanding of GHGs**

From the 30% of the managers that had a basic understanding of GHGs, mention was made that actions were needed and linked to monitoring the regulation of Chlorofluoro Carbons (CFC) and to encourage government to take action to eliminate GHGs. One manager indicated that GHG affects the climate. Regarding the operational employees, 30% had a basic understanding of GHG and mentioned that action is needed (2 employees), that there is an effect on the climate (1 employee) and the ozone layer (4 employees). The need to take actions, such as planting trees and providing cleaner vehicle fuels were mentioned.

Considering the responses from managers and operational employees regarding their opinions on the concept of greenhouse gases, two themes were apparent, (1) the lack of knowledge and misconceptions about GHGs and (2) the negative impact of GHGs and need for action.

5.4.1 Theme 1: Lack of knowledge and misconception of GHGs

The majority of employees, both managers and operations employees, did not know what the concept of GHGs meant. This highlights the need for Ekurhuleni Health District and provincial employees to educate their employees on the concept of GHGs. If the officials are educated on the subject, they could become motivated to reduce their carbon emissions. Some of the operational employees (17%) had misconceptions of the term GHGs. They believed that these gases were the good gases, which could reduce climate change. This belief might be attributed to the word "green", because the green colour in regarded as an environmental friendly colour. Below are some comments to illustrate the misconceptions.

> *"Greenhouse gases are there to decrease the air that is polluted";*
>
> *"Greenhouse gases are the go green gases. My opinion is that I hope it does change the climate change. I am not sure how it operates or what it does";*
>
> *"Greenhouses gases are good, because it will not affect the atmosphere so much and so we will not have the quick changes in climate"*
>
> *"I do not have much information about it, but I think it's vital because it also helps a lot with the climate"*.

5.4.2 Theme 2: Negative impact of GHGs and need for action

A small portion of both the managers (30%) and the operational employee (30%) had a basic understanding of the term GHGs. The majority of the respondents had an idea that GHGs is detrimental to the climate and atmosphere, as the responses below demonstrate.

> *"It's destroying our ozone layer";*
>
> *"They impact negatively on the atmosphere due to the depletion of the ozone layer"*;
>
> *"It refers to the gases that affect the ozone layer"*;
>
> *"I think these are gases such as CO_2, which affects the atmosphere"*;
>
> "*It's the carbon that affects the climate"*.

The participants made mention of the need to take action to reduce climate change. This action referred to (1) monitoring the regulation on Chlorofluoro Carbons (CFC) ("*GHG are regulated but there are challenges in terms of monitoring and we know that some gases are regulated such as CFC*"); (2) the elimination of GHG by government (*"the government should eliminate the GHGs and environmental people should advise the government on the ways to achieve this"*); (3) the need for action to be taken to reduce greenhouse gases, such as planting more trees (*"people must be encouraged to plant more trees, because trees help to clean up these gases"*); (4) the need for cleaner fuel for vehicles (*"they must try to manufacture cars that produce less of these gases"*). One participant believed that changes in the climate is already occurring, *"I think we are heading for trouble, because we can see changes in the weather and climate"*.

5.5 IMPORTANCE OF CLIMATE CHANGE

A question was put to the research participant: "How important is climate change to you?" Figure 5.11 shows the managers' responses where 60% of the managers indicated that climate change was important and gave valid reasons, 30% believed that climate change was important but did not give any reasons and only 10% were not sure.

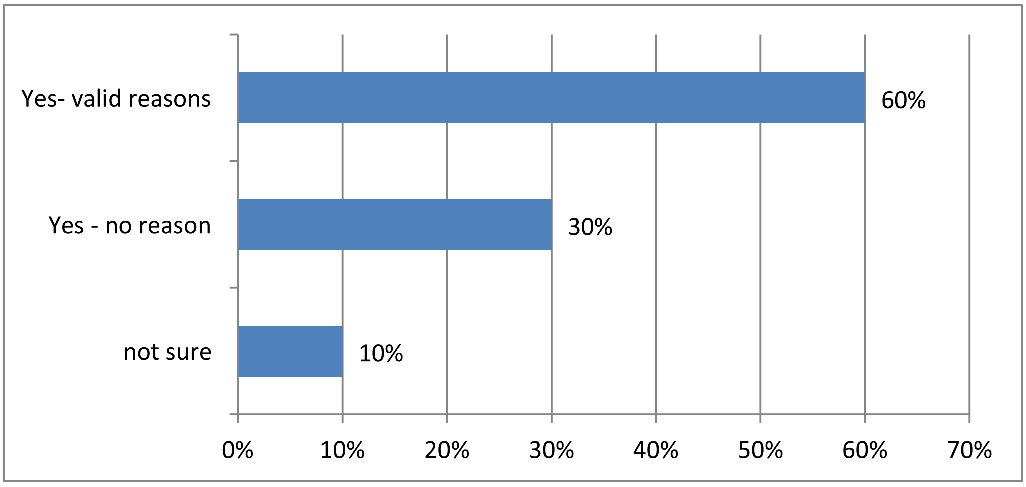

Figure 5.11 **Managers: Importance of climate change**

On the other hand, responses on the importance of climate change by the operational level employees is presented in Figure 5.12. Here 48% of the employees indicated climate change was important and gave valid reasons, while 17% also believed climate change was important but their reasons were invalid and 35% had no reasons for the importance of climate change.

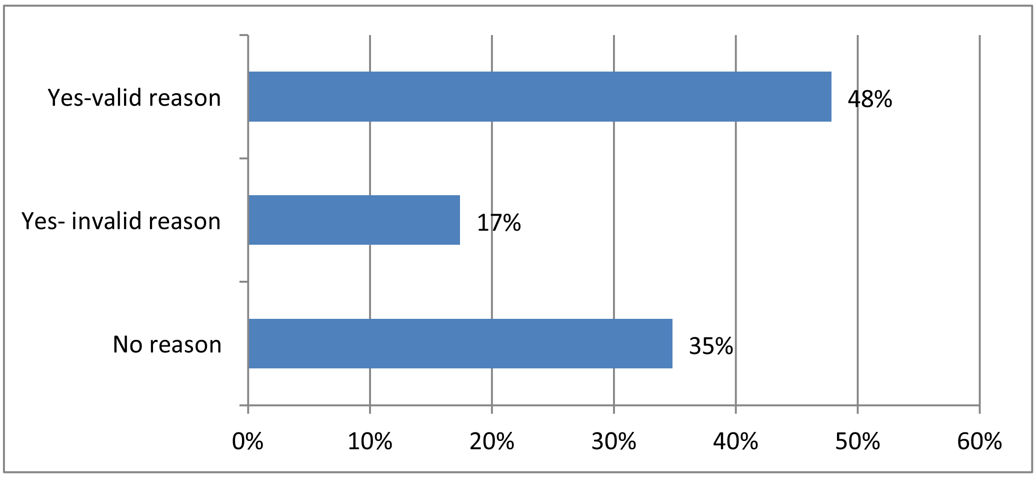

Figure 5.12 **Operational employees: Importance of climate change**

Some of the answers of the 17% of the employees who believed climate change was important and gave invalid reasons. Some examples of reasons follow:

> *"Yes, because it's natural. It can be raining and thunderstorm when you do not expect it to";*
>
> *"Yes it's very important. For example, it's hot when you are working in here. Then when there is a rain it cools you down and you open the window for fresh air."*
>
> *"It's important because sometimes we have plans, like this season we are going to farm";*
>
> *"It's important because we can't just have cold or hot weather. There must be a climate change between seasons."*

The possible reasons why managers believed that climate change was important were their concern about the future (50%) and the need for preventative measures (50%). The same reasons were mentioned by the operational employees where 55% were concerned about the future, while 45% appealed for the realisation of the importance of preventative measures. Thus, the two themes that arose were, (1) the uncertainty about the future and (2) the need for preventative measures.

5.5.1 Theme 1: Uncertainty about the future

Participants were concerned about the future due to climate change, especially for the future generations and their children. One participant indicated that the consequences of climate change is occurring at present and the effects will be experienced by the future generation. In addition, a participant was worried on how the world will be for her children if the issue of climate change is not addressed.

> *"It means that if we are affected now, how about the future generation? Our children will suffer the consequences"*).
>
> *"Yes it is. Considering that my children are still young, I wonder how the world would look, like two years from now, if we do not take care of our climate and environment"*.

An employee was worried about the future of his children, grandchildren and himself, while another employee believed that the world is coming to an end due to the sudden changes in climate.

> *"Yes it is important, because it's all about my future, my kids who will still live in this world and my grandchildren. So I think it's important that we take care of the environment so that our future generation are also protected and safe."*
>
> *"These days when you see the clouds gathering you think it's going to rain, but at the same time there is a strong wind and the sun is shining. It's scary. It seems as if the world is coming to an end"*.

5.5.2 Theme 2: Need for preventative measures

A participant indicated that the temperature is increasing and attributed this to the effects of climate change and highlighted the need for mitigation measures to be implemented.

> *"I come from a hot province (Limpopo) and now Limpopo is getting cooler while Gauteng is getting hotter due to climate change. We need to strengthen the proposal made by Environmental Affairs in terms of climate change."*

One employee believed that it is his responsibility to create awareness for the sake of the future generations and another highlighted the need to preserve the environment for the sake of the future.

> *"It is important to me, because I have to be part of the creation of awareness for the future generations."*
>
> "*It's important because we need to preserve the environment for current and future generations*".

Education as a means to reduce climate change was mentioned. Some participants indicated the benefits of reducing climate change for the society at large ensuring water and food security.

> *"It is important, because people must be educated to deal with climate change so that we actually reduce it in whatever way and so that it doesn't impact on our lives."*
>
> *"Society will be healthier. They will be able to go and work. We will have more plants and they will be able to do their own gardens."*
>
> *"If we can prevent climate change, we will have enough water and sunlight (for those things that need sunlight). Our environment will be OK. Animals will live and the food chain will not be disturbed."*

5.6 EFFECT OF CLIMATE CHANGE ON JOB DESCRIPTION

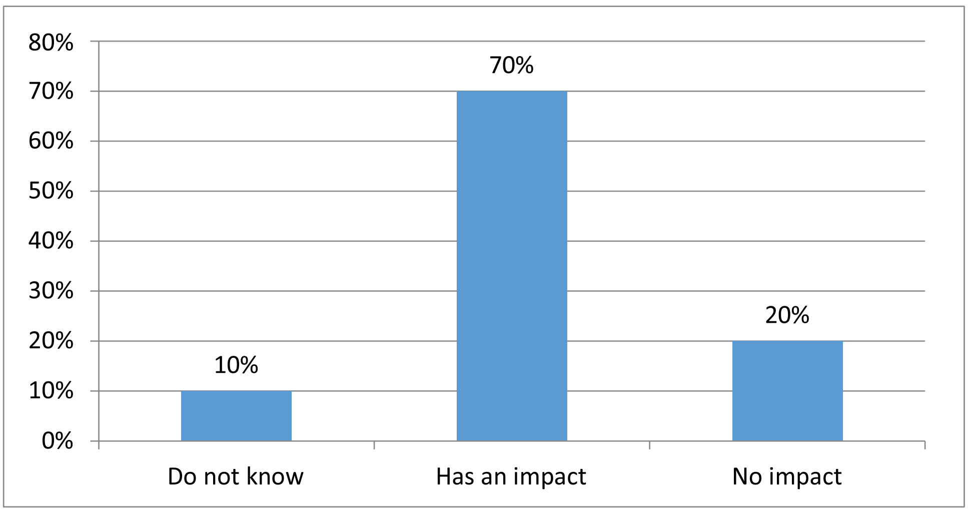

Figure 5.13 **Managers: Impact of climate change on job descriptions**

Regarding the responses of the employees to the question: “How would climate change affect your job description?” 70% of the managers indicated that climate change has an impact. Also 20% believed that it does not have an impact and 10% did not know (Figure 5.13).

Based on the keyword frequency of the managers’ responses to the impact of climate change on the job description, 44% believed that hospital admission or diseases would increase, while 33% mentioned that the occurrence of absenteeism would rise and 22% thought that it would impact on planning or activities. In terms of the response of the operational employees, 78% indicated that it has an impact, 17% did not know and 4% indicated no impact Figure 5.14).

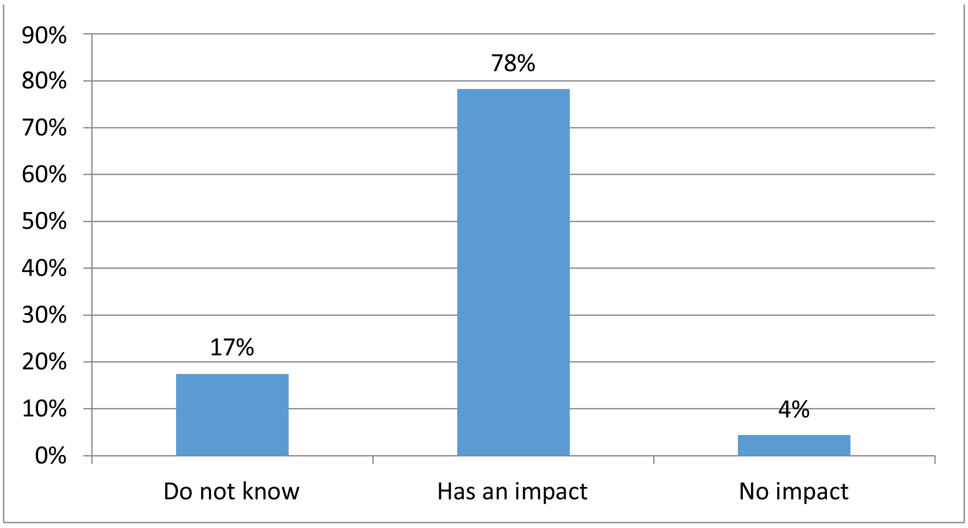

Figure 5.14 **Operational employees: Impact of climate change on job description**

Table 5.9 **Impact of climate change on job description of operational employees**

Keywords	**Frequency**	**%**
Increased hospital admission or diseases	7	37%
Impact on planning or activities	5	26%
Increase in work load	3	16%
Absenteeism	2	11%
Not safe	1	5%
Increase maternity (birth rate)	1	5%
Grand Total	**19**	**100%**

Table 5.9 presents the keyword frequency for the impacts of climate change on the job description for operational employees, the highest frequency (37%) was for an increase in hospital admission or diseases, followed by the impact on planning or activities (26%.), an

increase in the work load (16%) and absenteeism (11%). One respondent (5%) referred to the safety factor and another one (5%) to an increase in maternity (birth rate).

Three themes regarding the impact of climate change on the job description of employees that arose was: (1) increased hospital admissions or diseases; (2) impact on planning or activities; and (3) absenteeism.

5.6.1 Theme 1: Increased hospital admissions

Increased admissions or disease was the most recurring concern regarding job descriptions. Employees indicated that due to climate change there might be an increase in patients being admitted to hospitals and clinics due to the health status of the communities at large being affected by becoming more ill or unhealthy.

> "*With all the extra illnesses the clinic will be full. Instead of seeing 100 patients, we might see 150 and eventually 500 patients*".
>
> *"There will be more people admitted to hospitals and clinics*".
>
> *"It means that we will be dealing with a sick society. Instead of preventing diseases, we are going to have to deal with sick people".*

Although most participants mentioned sickness or diseases in general as possible effects on their job description, some participants were more specific by mentioning diseases, such as malaria, dehydration, diarrhoea, HIV and even behavioural effects of climate change.

> *"There would be an increase in malaria cases from people travelling from Maputo.*"
>
> "*Because of climate change, the weather is too hot causing babies to get dehydrated due to cases of diarrhoea."*
>
> *"If there is no rain, people will lose their jobs, and if people lose their jobs, they will start having more sex because they will not have anything to do. If protection is not used, it would increase the HIV statistic."*

5.6.2 Theme 2: Impact on planning and activities

Some participants felt that climate change might hinder them from achieving their work-related objectives and targets due to adverse weather conditions, such as heavy rainfall that might affect the progress of food gardening projects in the communities or might cause blackouts due to power failure. Poor concentration due to higher temperature in the office can also affect job description as mentioned by a participant.

> *"It can affect the way we conduct our services to the community, because if it is raining heavily we cannot go out to the clinics*".

"One of my key performance indicator (KPI) is to make sure that NGOs have food gardens, therefore, if it rains heavily or higher temperatures occur, it will delay the progress of the food gardens, which affects my job description."

"When it rains, the lightening affects the electricity causing blackout, which turns off my computer and hence I stop working."

"If you need to do office work and it's very hot, you cannot concentrate."

5.6.3 Theme 3: Absenteeism

Absenteeism from work was also mentioned due to the hampering of various transport infrastructures because of adverse weather conditions or being sick due to climate-related illness.

"The road will be flooded and I will not be able to come to work."

"I use the train and when it rains it affects the train sometimes."

"As I have mentioned before, if people are getting sick, there will be a lot of absenteeism from work."

"People get-off sick a lot and we have to investigate the reasons."

5.7 OPINION ABOUT IMPACT OF COP 17 IN SOUTH AFRICA

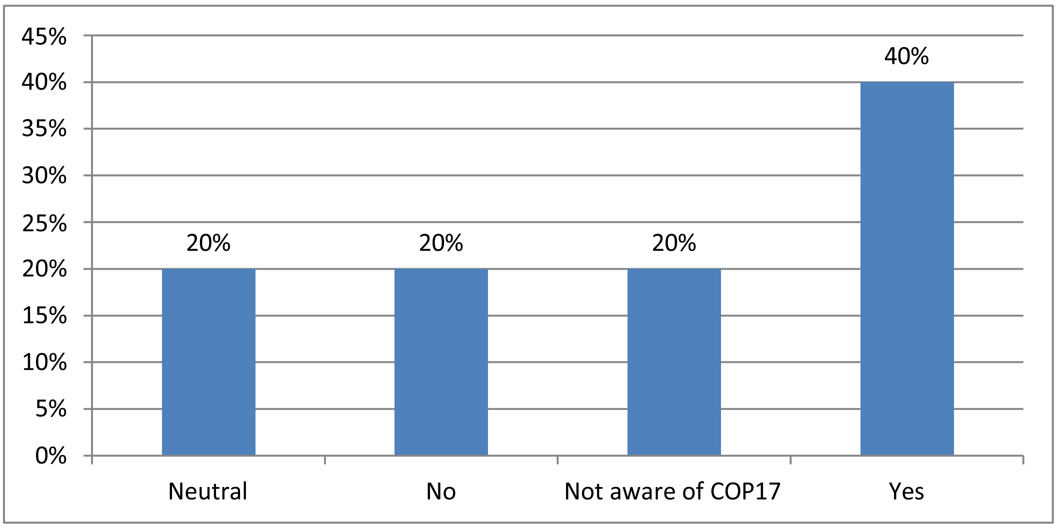

Figure 5.15 **Managers: Opinion about COP 17**

The following question was asked in this section: "What is your opinion about COP 17 held in Durban? Do you think it will have an impact in South Africa?" As can be seen in Figure 5.15, 40% of the managers indicated that COP 17 will have an impact, 20% believed that it will not have an impact, 20% were not aware of COP 17 conference and 20% were neutral.

In the case of the operational employees, 43% suggested that COP 17 will have an impact in South Africa, 30% were not aware of the conference, 9% declared that it will not have an impact, 9% did not know and 9% skipped or did not answer the question (Figure 5.16).

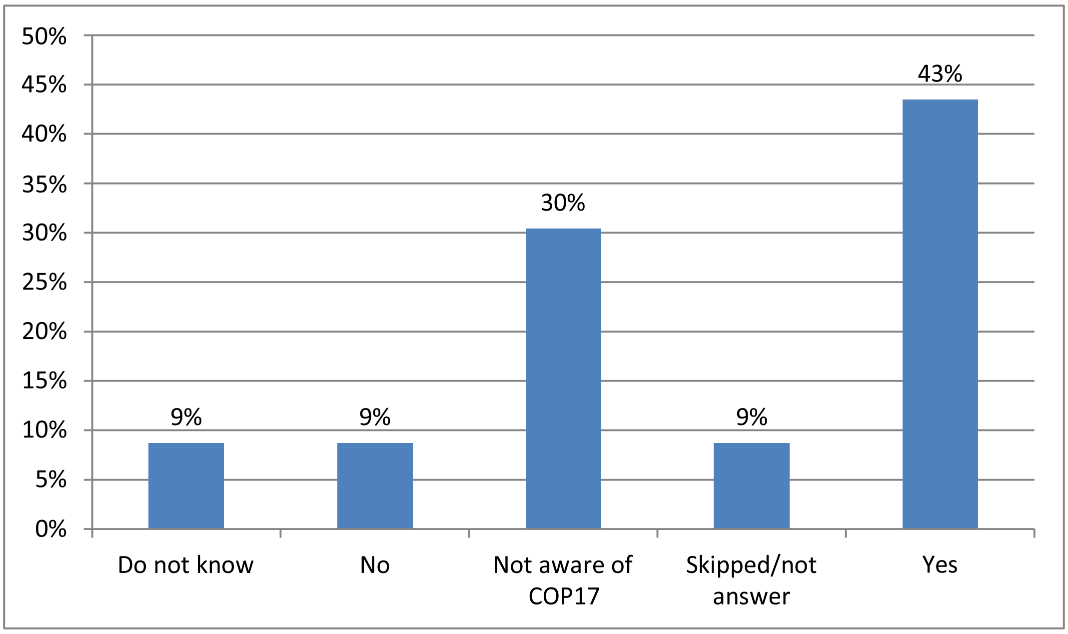

Figure 5.16 **Operational employees: Opinion about COP 17**

It is clear that the majority of the participants believed that COP 17 will have a positive impact in South Africa. However, there were some employees whom believed that the conference (COP 17) will not have an impact and some did not even know about the conference. Therefore, three themes emerged in this section: (1) the positive impact of COP 17; (2) no impact of COP 17; and (3) unaware of the conference.

5.7.1 Theme 1: Positive impact of COP 17

Regarding an optimistic view of the impact of COP 17 in South Africa, 40% of the managers and 43% of the operational employees were in agreement. They mentioned that it will be possible only if the agreements reached are implemented.

> *"Yes if people would have taken the resolutions reached there and implement them."*
>
> *"Yes it will, on condition that which was agreed upon are implemented."*
>
> *"… As long as it's not only talking, but the actual implementation of the decisions, then it will have an impact."*

Participants indicated that COP 17 created awareness of climate change and measures to implement actions and that South Africa has already started taking actions. COP 17 made them more knowledgeable on climate change.

Participants highlighted that the interaction among the different countries, including South Africa, will develop positive measures to combat climate change. One participant believed that since this conference was held in Africa, it exposed the other countries to the challenges of the continent. Furthermore, the idea of sharing with other countries was also mentioned.

> *Yes. It will have. South Africa is trying its best by planting more trees. COP 17 created more awareness on climate change and how to it."*
>
> "*It bring awareness to people. As for myself, I was not aware of climate change*".
>
> *"Yes, it will have, because different countries gathered in Durban to discuss climate change, ozone layer and greenhouse gases. With so many opinions and inputs, hopefully, there will be change."*
>
> "*Most of the things that are developed, such as guidelines, are based on those rich countries and they do not look at developing countries. Now, since this conference was held in Africa, those countries were exposed to it and now understand what is going on in Africa.*"
>
> *"The ideas we got from other countries on how to reduce climate change, is going to help because climate change does not affect us in South Africa only, but everybody in the world."*

5.7.2 Theme 2: No impact of COP 17

There were 20% of the managers and 9% of the operational employees who felt that COP 17 will not have an impact in South Africa, because there were no follow-up decisions or legislation and a lack implementation strategies.

> "*I do not see any legislation or follow-up on the decisions. We do not even know the decisions and it was just a talk show."*
>
> "*It ends up being a talk show. It does not have teeth to bite or push us to do something."*

Some employees believed that COP 17 will not have an impact in South Africa due to the lack of communication ("*I heard about the conference when it was starting but after that it was quiet*") and the absence of making changes by managers (*"I do not think our leadership is in the position to make any drastically changes"*).

5.7.3 Theme 3: Not aware of conference

20% of the managers and 30% of the operational employees were not aware of the conference held in Durban. This highlights the need to raise the public awareness and interest in climate change issues or conferences via other means.

5.8 WAYS IN WHICH DISTRICT OFFICE AND CLINICS CAN REDUCE CLIMATE CHANGE

Employees were asked the following question: *"is there a way on how the clinics and the district office can reduce climate change?"* Table 5.10 present the keywords frequency of the responses of the managers where 29% indicated vehicle control options, 24% power consumption measures, 10% planting of trees, 10% implementation of electronic system, 10% recycling and the rest of the options were 5% each as indicated in Table 40.

Table 5.10 **Managers' responses on way to reduce climate change**

Keywords	Frequency	%
Vehicles control options	6	29%
Power consumption	5	24%
Planting of vegetation or tress	2	10%
Electronic system	2	10%
Recycling	2	10%
Water	1	5%
Proper waste disposal	1	5%
Do not know	1	5%
Stop burning	1	5%
Total	**21**	**100%**

Table 5.11 **Operational employees' responses on ways to reduce climate change**

Keywords	Frequency	%
Education	7	29%
No, it cannot be reduced	3	13%
Vehicle control options	3	13%
Plant trees	2	8%
Do not know	2	8%
Power consumption	2	8%
Using bicycles	1	4%
Recycling	1	4%
Waste disposal	1	4%
Stop burning waste	1	4%
Stop cutting down trees	1	4%
Total	**24**	**100%**

On the other hand, operational employee's responses on ways to reduce climate change are presented in Table 5.11. Education (29%) was the most popular options, followed by: vehicle control options (13%); and 13% said there is no way in which clinics or the district can reduce climate change; 8% did not know how to reduce climate change; and 8% indicated planting trees and decreasing power consumption were attainable options. The rest of the options accounts for 4% each as seen in Table 5.11.

From these results, possible measures to reduce carbon emissions were vehicle control options, education, power consumption measures and other measures. Therefore, the general theme emerging from this question includes a number of measures to reduce carbon emissions.

Vehicle control options accounts for 29% of the responses of the managers and 13% of the operational employees. The options include sharing of vehicles, investigating and reporting vehicles which are emitting lots of smoke, the need for regular services of the government fleet vehicles and he need for less polluting type of fuel in government fleet vehicles.

> *"Sharing of vehicles when conducting support visits. For example four officials using one car instead of using four cars*."
>
> *"Sharing of vehicles during site visits i.e. using one car and dropping each other instead of driving four cars."*
>
> *"If there is lots of smoke being emitted, we should report this immediately so that something can be done, such as maintenance."*
>
> "*Investigations should be done especially on the cars emitting these gases.*"
>
> *"The cars should be serviced regularly to reduce emissions."*
>
> *"Controlling government vehicles and regular services of vehicles."*
>
> *"We can reduce emissions by using less polluting fuel, if available."*

The majority of operational employees (29%) believed that **education** was one of the options to reduce climate change. Educating people on subject of climate change, in particular targeting people who are not knowledgeable about climate change and the need to be trained or educated about the measures to reduce climate change.

> "*Educating people so that they can understand what climate change is.*"
>
> *"More education on the subject."*
>
> "*Targeting people whom are not educated on the effects of climate change on district level.*"
>
> *"We need specialists whom have knowledge of climate change and those whom are on those departments to come and educate us, so that we can spread the word."*
>
> *"I think if we are trained on how to reduce climate change, we can do it."*

Power consumptions control options were suggested by 21% of the managers and 8% of the operational employees. These options include, switching off lights in clinics when closed (*"Yes, we can reduce electricity consumptions at night in the facilities by switching off lights and appliances*), saving energy and the installation of solar panels (*Yes, things like solar heating"*).

Planting of vegetation options included gardens ("*We can go green planting vegetables and making gardens*") and trees (*"plant more trees"*). Some participants highlighted the need for the implementation of using the electronic system to save paper consumption (printing papers).

> *"We can go electronic to reduce the use of paper."*
>
> *"Reducing paper usage because paper is made from trees and using them will encourage trees to be chopped down and moving into paperless communication system."*

Recycling as an option for reducing climate change was suggested (*"maintaining the concept of reuse, recycling and reduce instead of coming up with new things. By doing this, we would try to reduce the impact of climate change").* Other options highlighted were water control, proper waste disposals, stop the burning of substances and start using bicycles.

5.9 CONCERN ABOUT THE FUTURE OF PLANET AND CLIAMTE CHANGE

Employees were asked: "Do you have a concern about the future of the planet and climate change?"

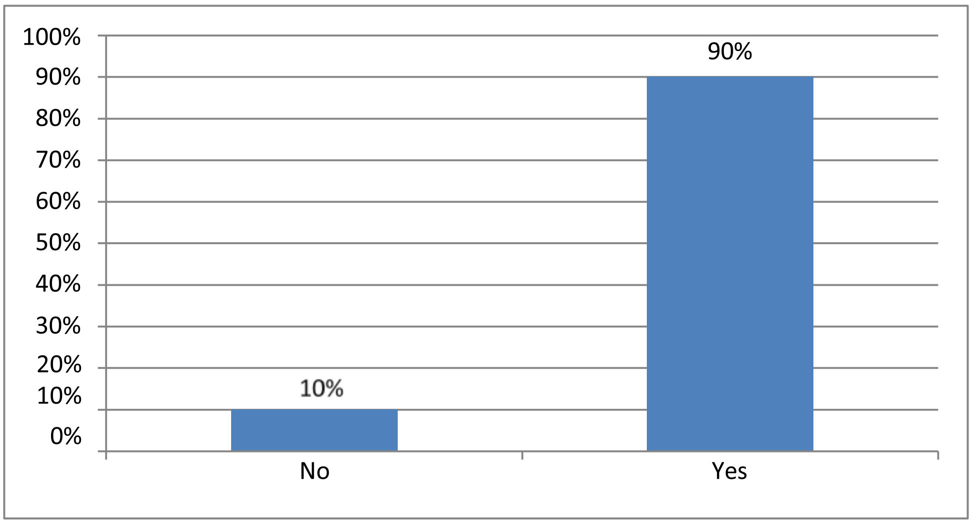

Figure 5.17 **Managers: Concern about climate change and the planet**

Figure 5.17 presents the managers' concern about the planet and climate change. Nearly all the managers (90%) were concerned about climate change and the planet and only 10% were not concerned.

More of the managers (33%) did not provide reasons for their concerns, however 22% indicated water pollution as their main concern, 22% referred to adverse weather conditions and 22% were concerned about the future generations. The majority (91%) of the operational employees were concerned about the planet and climate change, however, 4% did not know and 4% said "NO" they were not concerned about the planet and climate change (Figure 5.18).

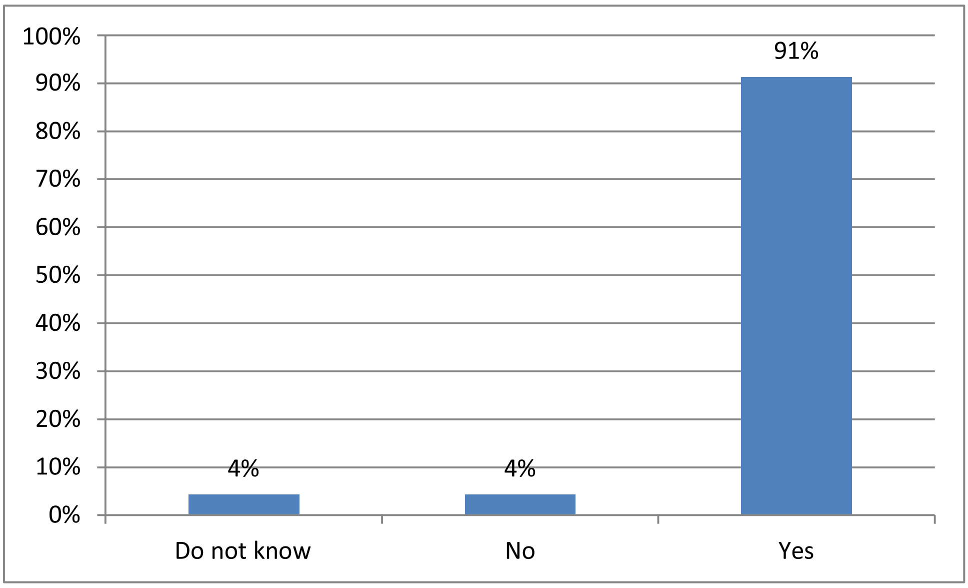

Figure 5.18 **Operational employees: Concern about climate change and the planet**

The concerns of the operational employees were expressed by 43% who were worried about the future generations and 29% about adverse weather conditions, while 19% did not respond and 10% were concerned about diseases.

Considering these results, the majority of employees (90% managers and 91% operational employees) were concerned about the future of the planet and climate change. Therefore, the possible theme emerging in this section is the concerns of employees (90% of the managers and 91% of the operational employees) about the future of the planet. There reasons varied from adverse weather conditions, the future generation, water pollution and disease. Below are some of the statements made by the employees.

Unpredictability of the weather

> *"We do not enjoy the seasons anymore. It is summer now and we are experiencing rains, thunderstorms and cold weather."*
>
> *"I am already worried because the weather these days is not OK. It changes anytime."*

> *"Yes. It's scary, especially for those people living in the coastal areas. We are not sure if they will be affected by a tsunami."*
>
> *"Sometimes we become worried, for example its summer now and its cold. You wonder what going to happen in the future."*

Impact of droughts on food security and water

> *"If climate change continues as it is going now… we might have problems with food supply and water."*

Uncertainty of the future for the future generation and quality of life

> "*Our children are growing up in this planet; we only want to see good things happen."*
>
> *"Yes I do, especially because I have a daughter."*
>
> "*Yes, where will our grandchildren live?"*
>
> *"Human beings will not be able to tolerate and the environment will not be able to sustain us"*
>
> *"Yes, because when there is no rain the animals and trees will die."*
>
> "*We should be concerned about the future and be more proactive than reactive."*
>
> *"If we do not prevent climate change we will die."*
>
> *"Yes, because if nothing is done very quickly and effectively, the future of our planet is questionable."*

Water pollution and diseases

> "*Even the fishes we are getting, you can see are not healthy. They have red lesions and things. I think it's the water pollution."*
>
> *"We are pouring oils into the seas."*
>
> *"Yes, I am concerned, because it will result in people getting sick."*
>
> *"Eruption of a volcano where the steam is dangerous to the human. It can cause illnesses to the lungs."*

5.10 CONCLUSIONS ON KNOWLEDGE AND PERCEPTION OF CLIMATE CHANGE AMONG EMPLOYEES

Employees were asked two demographic-related questions and nine questions where four questions determined knowledge and the remaining five questions assessed the perceptions of the employees to climate change (see Appendix D for interview questionnaires guide). A total of 33 employees were interviewed of which 30% (n=10) were managers and 70% (n=23) were operational employees.

5.10.1 Knowledge of climate change among managers and operational employees

The knowledge of the managers and operational employees on climate change encompassed six themes, namely: climatological changes, human-induced climate change, adverse weather conditions, an increase in the occurrence of diseases, lack of knowledge and misconception of GHGs, the negative impact of GHG and the need for action.

5.10.2 Understanding of climate change

Most employees, for example 100% of the managers and 87% operational employees, demonstrated a basic understanding of climate change. The employees' understanding of climate change was based on changes in the climate. This may be attributed to personal experience of the weather changes, such as unpredictability of rain and seasons and how the weather in general has changed during the past years. Temperature variation (too hot and too cold) was also linked to their basic understanding. Employees believed that temperature increase is due to carbon dioxide emissions in the atmosphere. Only 13% of the operational employees did not have a basic understanding of climate change.

5.10.3 Causes of climate change

On the causes of climate change, 70% of the managers and 87% of the operational employees could provide the correct answers. The employees' responses to the causes of climate change were mainly human-induced activities, such as burning of coal, driving vehicles, operating in industries and experiencing pollution. However, 20% of the managers gave incorrect answers and another 10% said they did not know what the causes of climate change are. On the other hand, 13% of the operational employees gave incorrect answers.

5.10.4 Consequences of climate change

All the employees mentioned the correct consequences of climate change, such as direct emissions (adverse weather), indirect effects (diseases) and other counter-effects of climate change. The most outlined consequence of climate change was adverse weather conditions. Employees mentioned heavy rainfalls, thunderstorms, droughts and increased temperatures. Furthermore, they also mentioned the counter effects of adverse weather conditioners on crops, animals and farmers. The second most mentioned consequence of climate change among the employees was the increased incidence of disease. Emerging diseases, such as malaria was a concern and an increase in respiratory illness, which complicated tuberculosis. Heat stroke due to increase temperatures was also pointed out.

5.10.5 Concept of greenhouse gases (GHGs)

Employees were asked about their opinion on greenhouse gases. The majority of the employees (70% managers and 70 % operational employees) did not have knowledge of the concept of GHGs. This suggests there is a need for Ekurhuleni Health District and provincial employees to educate their employees regarding GHGs. If employees are educated on the topic, they might become motivated to reduce emissions. Lack of knowledge on the concept of GHGs may be attributed to the term “green”, which causes confusion and misconceptions, such as the that the colour “green” is regarded as an environmentally friendly colour. The other 30% of the managers and operational employees believed that GHGs is detrimental to the atmosphere and suggested ways of reducing the GHG emissions, such as planting trees, using of cleaner fuels and the regulation of Chlorofluoro Carbons.

5.10.6 Perception of climate change among managers and operational employees

The perceptions of climate change among the managers and operational employees resulted in ten themes, namely: uncertainty of the future; the need for preventive measures; increase in patient admissions to hospitals; impact on planning and activities; absenteeism; positive impact of COP 17, no impact of COP 17; unawareness of the conference; measures to reduce carbon emissions; and employees concern about the future.

5.10.7 Impact of climate change on job description

The majority of the managers (70%) and the operational employees (78%) were of the opinion that their job description will be affected by: climate change due to the increased number of patients admitted to hospitals; the impact it will have on planning and activities; and the occurrence of absenteeism. Regarding the increase in the patients admitted, the employees were of the opinion that climate change result in an increase in diseases and illnesses, such as malaria and dehydration in the communities. As a result, more patients will seek medical attention from the hospitals and clinics.

Some participants felt that the effect of climate change might hinder them from achieving their work-related objectives due to adverse weather conditions, for example rendering health services in the communities could be reduced, due to heavy rainfalls which prevent employees from going out to the clinics. Projects, such as food gardens of the non-governmental organisations (NGOs) will be affected due to floods and heavy rainfalls. Poor concentration in office as a result of increased temperature, power supply disruptions was also anticipated. Increased absenteeism from work due to damage of transport infrastructure and increased illnesses were concerns among the employees. However, 20% of the managers felt that climate change will not have an impact on their job description and 10% indicated, “Do not know”. On the other hand, 17% of the operational employees indicated, “Do not know” and the other 4% believed that climate change will not have an impact on their job description.

5.10.8 Employees viewed climate change as an important factor

On asking the question of how important climate change is, 90% of the managers felt that it was important. Of these managers, 60% provided valid reasons for its importance, and 30% did not give any reason and 10% were not sure if climate change was important to them. Regarding the operational employees, 65% viewed climate change as important of which 48% gave valid reasons while 17% gave invalid or incomplete reasons. While the remaining 35% of the operational employees could not give any reasons of the important of climate change.

The majority of the employees viewed climate change as an important factor because of the general concern regarding the future, especially where the future generation was concerned. This might possibly be as a possibility that the majority of the employees being parents and raising their children. Some participants were convinced of the consequences of climate change that will affect their children in the future if actions are not taken immediately. Possible preventative measures to reduce climate change was suggested by employees, such as a convincing proposal by the Department of Environmental Affairs (DEA) to preserve the environment and educating the public to use ways to reduce climate change.

5.10.9 Perception of impact of COP 17 in South Africa

A number of managers (40%) believed that COP 17 will have a positive impact in South Africa, while 20% felt that it will not have an impact. Another 20% of the managers were not aware of COP 17 and 20% were neutral. In the case of the operational employees, 43% were positive about the impact of COP 17 in South Africa. However, 30% were not aware of COP 17. A few (9%) believed it will not have an impact, while 9% indicated “Do not now” and 9% asked to skip the question mention.

Nevertheless, the majority of employees were optimistic about the impact of COP 17 in South Africa. The participants indicated that the success of COP 17 in the South African context resides in the implementation of the decisions made during the conference. One participant mentioned that COP 17 has already influenced South Africans by creating an awareness of climate change and motivating them to reduce climate change.

Some employees believed that COP 17 will not have an impact in South Africa. The reasons provided for this include the lack of follow-up guidelines or the introduction of legislation and the absence of implementation strategies. It is also important to note that some employees were not aware of COP 17. This points to the need to raise public awareness of climate change issues via other means.

5.10.10 Suggested measures to reduce climate change in district offices and clinics

A question was asked about the ways in which the District Office and provincial clinics could reduce climate change. Vehicle control was the most mentioned measure and suggestions included sharing of the government fleet vehicles, reporting vehicles that emit lots of smoke, regular maintenance of vehicles and the use of less polluting fuel. Employees felt strongly that education, as a measure to reduce climate change, must be implemented and pointed out the need to attend training on climate change for themselves.

Power consumption control options were proposed, such as: switching off lights and appliances at night in clinics; saving energy and the installation of solar panels. Other measures included planting of trees, the implementation of electronic systems to reduce paper consumption, using bicycles and water and waste control.

5.10.11 Concern of employees about the future of the planet and climate change

The majority of the employees, 90% of the managers and 91% of the operational employees, were concerned about the future of the planet and climate change. However, 10% of the managers were not concerned while 4% of the operational employees indicated “Do not know” and 4% showed no concern for the planet and climate change.

5.11 SUMMARY ON KNOWLEDGE AND PERCEPTION OF CLIMATE CHANGE

Most of the employees demonstrated basic knowledge of climate change. All the mangers and operational employees knew the consequences of climate change. The operational employees (87%) had better understanding on the causes of climate change than the managers (70%).However, the majority of managers (70%) and operational employees (70%) lacked knowledge on concept of greenhouse gases (GHGs), this may be attributed to the word “green” that causes confusion and misconception. In terms of perception of climate change, 90% of the employees viewed climate change as an important factor and were concerned about the future of the planet. Most believed that climate change will have an impact to their job description.

Chapter 6

RECOMMENDATIONS AND CONCLUSION

This chapter presents recommendations, which Ekurhuleni Health District Office and provincial clinics may implement, to reduce their carbon emissions. As indicated in Chapter 4 (4.6.1), Scope 2 indirect emissions consists of electricity consumption, which produced the highest CO_2e emissions of 35150 t CO_2e and accounts for 92% of the total carbon footprint. Scope 1 direct emission comprises of the government fleet of vehicles, which produced 1362 t CO_2e and accounted for 4% of the total carbon footprint from January 2010 to December 2014. Scope 3 indirect emissions consists of information and communication technology (ICT), which accounts for 2% of the total carbon footprints, office paper (1%) and air conditioners (1%) and emitted 862 t CO_2e, 181 t CO_2e and 458 t CO_2e emissions respectively, from January 2010 to December 2014. Possible recommendations on Scope 1, 2 and 3 are presented.

This chapter concludes with the research objectives of the study, which are (1) to estimate the carbon dioxide equivalent emissions of Ekurhuleni Health District Office and provincial clinics, (2) To identify potential mitigation strategies to reduce carbon emissions and (3) to determine the knowledge and perception of climate change among managers and operational employees in the District Office and Provincial Clinics.

6.1 SAVINGS AND REVENUE GENERATION FOR RECOMMENDATIONS PROPOSED

Ekurhuleni Health District and Provincial Clinics are part of Gauteng Department of Health (GDoH) and therefore share the same mission which is “to contribute towards the reduction of the burden of diseases in all the communities in Gauteng” (Department of Health, 2016). However, this mission is under threat due to the direct (storms, drought and floods) and indirect impacts (increased food-borne, water-borne, malnutrition and death due to heat waves) of climate change on the public health sector. Therefore, it is essential for Ekurhuleni Health District to take measures to reduce their contribution to climate change.

If Ekurhuleni Health District and Provincial Clinics implement the recommendations in this study, these facilities will not only be implementing measures to reduce the health impact of climate change in their facilities, but also saving money from fuel and electricity and the potential revenue generating opportunities by registering a project with Clean Development Mechanism. Table 6.1 present dual benefits, firstly from electricity and fuel saving and secondly by revenue generation from certified emission reduction (CER) points. This implies that, for example the use of electrical vehicles, substituting desktops with laptops and substituting HFC-23 air conditioner refrigerant with R410A, will reduce the carbon emissions by 2445 t CO_2e for the period of five (5) years. These recommendations will also save the district and provincial office R7 875 089 from fuel and power consumption for the same period. In additional, the district office can generate R293 040 by registration for CMD project for five years or R1 173 600 for the duration of the project (20 years).

Table 6.1 **Opportunities for CO_2e emissions reducing, saving and revenue generation**

Scope	Recommen-dations	Electricity & fuel savings	t CO_2e Reduction (5 years)	CER Units	CDM Revenue (5years)	CDM Revenue (20years)
1	Electrical Vehicles	R 7 089 089	1362	1362	R 163 440	R 653 760
1	Toyota Yaris Hybrid	R 4 108 373	853	853	R 102 360	R 409 440
1	Toyota Auris Hybrid	R 3 859 982	797	797	R 95 640	R 383 560
1	Toyota Prius Hybrid	R 4 025 572	822	822	R 98 640	R 394 560
3	Laptops	R 786 000	675	675	R 81 000	R 324 000
3	Air condition (R401A)	N/A	408	408	R 48 960	R 195 840
	Total*	R7 875 089	2445	2445	R293 400	R1 173 600

*Based on electrical vehicles, laptops and air conditioners

6.2 RECOMMENDATIONS FOR SCOPE 1 EMISSIONS

Government fleet vehicles accounts for 4% (1 362 t CO_2e) of the total carbon footprint of Ekurhuleni Health District and provincial clinics from January 2010 to December 2014. This result shows the importance of implementing carbon reduction measures to reduce the carbon emissions associated with government fleet vehicles. The following measures are recommended.

6.2.1 Hybrid vehicles

Hybrid vehicles use the latest technology of combining the petrol engine with electrical powered battery (Romm, 2006:2612). A study conducted by Thomas (2009:9294) showed that the best way in reducing transport carbon emissions was to use vehicles powered by alternative fuels, other than petrol. The hybrid system is fitted with petrol and electric systems. The electric motor in the vehicles does not need to be recharged ever, due to the internal combustion technology (Toyota, 2016). Current models available in South Africa include Toyota Auris-Hybrid, Toyota Prius-Hybrid and Toyota Yaris Hybrid, these models has a CO_2 emission factor of 91g/km, 87g/km and 82g/km respectively (Toyota, 2017a, b, c).

Considering the petrol efficiency of the hybrids vehicles, it is recommended that Ekurhuleni Health District and the provincial clinics make use of these vehicles. Table 6.2 presents the total kilometres travelled and the CO_2e emissions of the current vehicles versus the CO_2e emissions of hybrid vehicles from January 2010 to December 2014.

Table 6.2 **CO_2e emissions for the current vehicles versus hybrid vehicles**

Years	KM travelled	t CO_2e current vehicles	t CO_2e Toyota Auris Hybrid	t CO2e Toyota Prius Hybrid	t CO_2e Toyota Yaris Hybrid
2010	1209431	252	110	105	99
2011	1425973	328	130	124	117
2012	1217691	277	111	106	100
2013	1019616	222	93	89	84
2014	1334008	283	121	116	109
Total	**6206719**	**1362**	**565**	**540**	**509**

From 2010 to December 2014, the CO_2e emissions of the current vehicles was 1362 t CO_2e. The implementation and use of the Toyota Auris-Hybrid vehicles in the District office and provincial clinics will reduce the emission by 797 t CO_2e (1362 - 565) for a five-year period, which accounts for 58% (797/1362*100) reduction in CO_2e emissions. The use of the Toyota Prius-Hybrid vehicle will reduce the CO_2e emissions by 60% (822/1362*100) to 822 t CO_2e emissions (1362 – 540) and finally, the use of the Toyota Yaris Hybrid vehicle will reduce the CO_2e emissions by 62% (853/1362*100) to 853 t CO_2e (1362 – 509) for the five year period.

The CO_2e for the hybrid vehicles were calculated as follows. For example, Toyota Yaris Hybrid has a CO_2 emission factor of 82g/ km (Toyota, 2017c). If this vehicle was used by the District office in 2010, the vehicle could have travelled 1 209 431km in 2010. The resultant emissions in 2010 could have been 110 t CO_2e (1 209 431km * 3.6 g/km / 1 000 (converting grams to kilograms) / 1 000 (converting kilograms to tons).

Figure 6.1 shows CO_2e emissions for the current vehicles versus hybrid vehicles. It can be seen that the current vehicle produced 1362 t CO2e and the implementation of hybrid vehicle will have released 565, 540 and 509 t CO_2e for Toyota Auris-Hybrid, Toyota Prius-Hybrid and Toyota Yaris Hybrid respectively for January 2010 to December 2014.

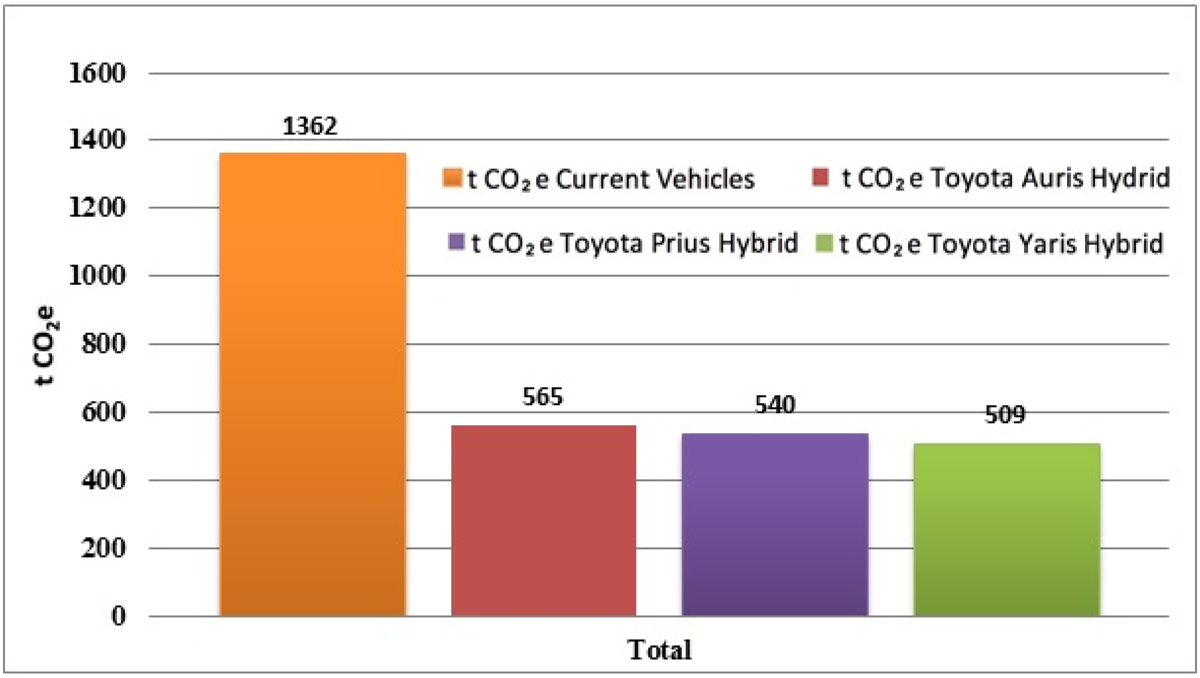

Figure 6.1 **Graphical presentations of CO_2e emissions for the current vehicles versus hybrid vehicles**

Table 6.3 **Current fuel consumption rate versus hybrid vehicles consumptions**

Years	KM travelled	Current Fuel used	Fuel used Toyota Auris	Fuel used Toyota Prius	Fuel used Toyota Yaris
2010	1209431	96 410	47168	44749	43540
2011	1425973	129 296	55613	52761	51335
2012	1217691	111 673	47490	45055	43837
2013	1019616	86 899	39765	37726	36706
2014	1334008	107 138	52026	49358	48024
Total	**6206719**	**531416**	**242062**	**229649**	**223442**

The implementation of hybrid vehicles in Ekurhuleni Health District and provincial clinics will result in the fuel saving. The fuel consumption rate (1L/km) of the hybrid vehicles were 3.9L/km, 3.7L/km and 3.6L/km for Toyota Auris-Hybrid, Toyota Prius-Hybrid and Toyota Yaris Hybrid respectively (Toyota, 2017a, b, c). The hybrid vehicles fuel consumptions were calculated as follows. For example, Toyota Auris total fuel consumption in 2010 would have been 47168 L (1209421 km / 100 * 3.9L/km).

Table 6.3 shows total fuel consumed by current vehicles versus hybrids vehicles. The current vehicles used 531 426L of petrol in the 5-year period. Toyota Auris Hybrid vehicles will use 289354L (531416L – 242062L) less fuel, which is 54% (289354L/ 531416L*100) for the same period of five years, while Toyota Prius Hybrid will use 301767L (531416L - 229649L) less fuel which accounts for 57% (301767L/531416L * 100) and Toyota Yaris Hybrid will use 307974 (531416L - 223442L) less fuel, which is 58% (307974/531416L * 100).
The implementation of hybrid vehicles will not only save fuel, but also money in the long term. Figure 6.2 indicates possible saving of different hybrid vehicles and current vehicles. With the calculation, it was assumed that a litre of petrol cost R13.34c. Using the Toyota Auris Hybrid will save the District Office R3 859 982 for the period of five years. The Toyota Prius Hybrid will save the District Office R4 025 572 and the Toyota Yaris Hybrid will save R4 108 373.The limitation of the hybrid vehicles CO_2e emissions reduction and fuel saving options are based on the manufacturer emission factors and fuel consumption rate, which might be influence by the vehicles maintenance status and driving habits.

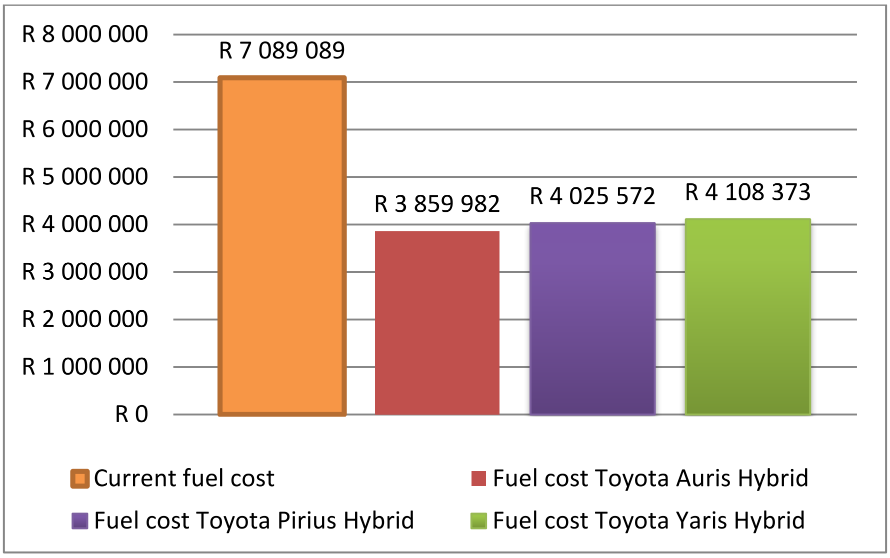

Figure 6.2 **Costs saving from petrol for hybrid vehicles for a 5-year period**

6.2.2 Electrical vehicles

The Department of Environmental Affairs (DEA) launched the DEA green car project on 26 February 2013 in partnership with Nissan. The aim of the project was to pilot the zero-emission electrical vehicles and to influence government institutions to adopt the concept of green vehicles in their fleet. The Department has built a charging infrastructure powered by solar energy for the electrical vehicles (DEA, 2016). An example of an electrical vehicle available in the South African market is Nissan LEAF. This vehicle uses ground-breaking technology with a lithium-ion battery, which needs to be charged at home or on the road (Nissan, 2016). Nissan LEAF can travel up to 195km when fully charged. It takes approximately seven hours to charge. There are currently nine charging stations in Gauteng (Supergroup dealership, n.d.).

Considering the above advanced technology spear-headed by DEA, the Ekurhuleni Health District can consider options when obtaining these vehicles. By implementing the use of electrical vehicles, the district office will reduce Scope 1 emissions to zero and saving the Department R7 089 089 in fuel for a five-year period (at R13.34 per litre of petrol). The assumption of the electrical vehicles recommendation is based on the District Office obtaining charging stations located at their respective facilities, derived from non-fossil fuel source, such as solar energy.

6.2.3 Improving driving habits

It is recommended that the officials at the district offices and provincial clinics be encouraged to improve their driving methods. The improvement of driving methods will reduce the carbon emissions from fleet vehicles to some extent (EPA, 2016). The Environmental Protection Agency (EPA) (2016) recommends the following measures while driving.

- Driving cautiously by preventing rapid accelerating and breaking;
- Monitoring the speed limit by avoiding speeding; and
- Reducing engine idling.

In addition, Smith (2011:43) suggested that improving the aerodynamics of the vehicle will increase the efficiency of the vehicle and hence reduce the carbon emissions, such as making sure the vehicle tires are well inflated and reducing speed. Planning the route is important, as this will decrease the kilometres travelled for the trip.

6.2.4 Telle-conferencing

The use of technology of ICT equipment, such as video-conferencing or telle-conferencing allows employees to reduce unnecessary trips to attend meetings. This technology can be used to reduce the carbon emissions from vehicles (Woodcock *et al*., 2007:1084). Furthermore, Smith (2011:33) concurs that the use of ICT equipment for video-conferencing can reduce the carbon emissions associated with travelling for work-related meeting. It is recommended that the Ekurhuleni Health District office and the provincial clinics be fitted with telle-conferencing technologies in their conference room, which will reduce the travelling to meetings and saving time.

6.3 RECOMMENDATIONS FOR SCOPE 2 EMISSIONS

Scope 2 indirect emission from electricity accounts for 92% (35150 t CO_2e) of the total carbon footprint for the period of five years in the Ekurhuleni Health and provincial clinics facilities. The following measures can reduce power consumption and thus affect the carbon emissions, as indicated by Eskom (2016b, c, d).

- Install solar panels or photovoltaic (PV) in buildings. It utilise renewable energy and has zero CO_2e emissions. Office appliances (overhead projectors) can also be connected to the PV system.
- Install solar geysers that can reduce energy cost by 24% because it uses sun rays to heat water.
- Motion sensor lighting can be fitted in bathrooms.
- Avoid placing appliances on standby mode. Equipment on standby mode consumes 15% of the electricity that it normally uses.
- Replace incandescent light bulbs with fluorescent, as fluorescent is more efficient and uses less power.
- In winter, make sure the building is properly insulated to make the heat more efficient by preventing cold air into the building.

6.4 RECOMMENDATIONS ON SCOPE 3 EMISSIONS

Scope 3 emissions consist of indirect emissions from Information and Communication Technology (ICT), office paper and air conditioners. The study showed that the carbon emissions from ICT was 862 t CO_2e which accounts for 2% of the total emissions of Ekurhuleni Health District Office and the provincial employees from January 2010 to December 2014. The carbon emissions from office paper was 181 t CO_2e, which accounts for 1% of the total carbon footprint. Carbon emission from air conditioners was 458 t CO_2e accounts for 1% of the total carbon footprint. The implementation of the following measures are recommended to reduce Scope 3 emissions.

6.4.1 Substituting personal desktops with laptops

ICT equipment, such as computers, plays a vital role in every organisation. Computers are used for communication, report-writing, research, etc. Most companies assign computers to each employee, making the quantity considerable (Tjandra *et al.*, 2015:4186). Personal desktops consist of monitors and central processing units (CPUs). The Ekurhuleni Health District and provincial clinics had CPU small factor, CPU convertible and desktop monitors. This equipment consumed 123 074kWh, 583 771kWh and 69 485 Kwh of electricity respectively from January 2010 to December 2014, emitting 129 t CO_2e, 613 t CO_2e and 73 t CO_2e respectively (see Chapter 4, section 4.5).

Table 6.4 shows the total carbon dioxide equivalent emissions and the average electricity consumption used by ICT equipment from January 2010 to December 2014. Since personal desktops consist of monitors and CPUs, the combined five years emission and electricity consumption of personal desktop was 815 t CO_2e and 766 330kWh respectively, when considering the 232 units of personal desktops in operation.

Table 6.4 **CO_2e emissions and electricity consumptions used by ICT equipment from January 2010 to December 2014**

ICT Variables	t CO_2e	Power consumption (kWh)	Number of equipment
CPU convertible	613	583 771	175
CPU small factor	129	123 074	57
Monitor	73	69 485	227
Laptop	24	23 311	46
Printer	18	17 146	181
Cell phone	5	4 532	130
Total	**862**	**821 319**	**816**

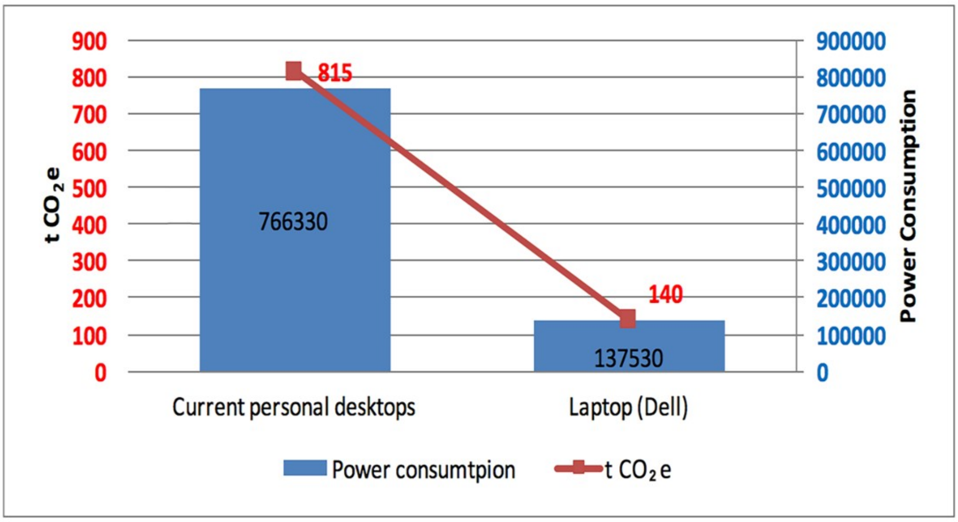

Figure 6.3 **CO_2e emissions and power consumptions for personal desktops versus laptops**

If the Ekurhuleni Health District Office and provincial clinics substitute the 232 personal desktops with laptops of equal number (Figure 6.3), for example Dell Latitude E5540 with 65 watts, the total consumption of electricity from the laptops will be 137 530kWh for a five-year period (derived from power consumption equation from Chapter 3 in section 3.6.4.1). The total carbon emissions from these laptops for five (5) years will be 140 t CO_2e (derived from Use stage GHG emission equation from Chapter 3 in section 3.6.4.1, while considering the average Eskom emission factor of 1.05kg CO_2e/kWh).

By substituting personal desktops with laptops throughout the district office and the provincial clinics, the Department will reduce 675 t CO_2e (815 t CO_2e – 140 t CO_2e) emissions for the five-year period. In addition, the Department will save in a five-year period 628 800kWh (766 330kWh – 137 530kWh), which amounts to R786 000 (at R1.25c per kWh). Song *et al*. (2016:275) reported that 50% of the emissions of ICT can be reduced by replacing desktops with laptops.

6.4.2 Power saving options

Information and communication technology (ICT) equipment uses electricity, which results in carbon emissions. Therefore, encouraging employees to save power will reduce the carbon emissions from ICT equipment, such as personal desktops, laptop, printers, etc. The Green ICT Tips (2016) suggest the following options:

- Turn off the computer when not in use;
- Avoid using screensavers as it consumes power by preventing the screen from dimming;
- Switch off the computer if you are away from your work station for more than 10 minutes or attending a meeting;
- Unplug the electrical cord of the equipment from the electricity circuit, leaving the electrical cord plugged in will draw small amounts of power even, if the equipment is switched off.

6.4.3 Substituting HFC-23 air conditioner refrigerant with R410A

The CO_2e emission from the air conditioners from January 2010 to December 2014 was 475 t CO_2e which accounts for 1% of the total carbon footprint of the Ekurhuleni District Office and provincial clinics. Current types of air conditioner refrigerant found in the facilities were HFC- 23 with a global warming potential of 117000 and R410A with a global warming potential of 1725.

Table 6.5 shows that 475 t CO_2e emissions were emitted from facilities with R410A and HF-23 air conditioner refrigerant for 5 year period. Most facilities had HFC-23 types of refrigerant (excluding Nokuthela Ngwenya and Kwa-Themba) which emitted a total of 458 t CO_2e emission (Table 6.5).

Table 6.5 **Average CO_2e emissions associated with HFC 23 and R410A air conditioners refrigerant for a five-year period**

Facilities	Number of Air conditioners	t CO2e 5 years	HF-23 t CO2e	R410A t CO2e
District Office	88*	154.44	154.44	22.77
Jabulani Dumani	20*	35.10	35.10	5.17
Phillip Moyo	20*	35.10	35.10	5.17
Ramakonopi	20*	35.10	35.10	5.17
Mary Moodley	20*	35.10	35.10	5.17
Esangweni	20*	35.10	35.10	5.17
Phola Park	20*	35.10	35.10	5.17
Isabella	20*	35.10	35.10	5.17
Andries Radisela	20*	35.10	35.10	5.17
Nokuthela Ngwenya	62#	16.04	-	-
Northmead	9*	15.80	15.80	2.33
Magagula	4*	7.02	7.02	1.03
Kwa-Themba	4#	1.04	-	-
Grand total	**327**	**475**	**458**	**67**

* Facilities with HFC-23 #Facilities with R410A

There is an opportunity for emission reduction by using R410A air conditioner refrigerant types. If Ekurhuleni Health District and provincial clinics substitute the HFC-23 refrigerant air conditioner types with 261 R410A refrigerant air conditioner types, the total CO_2e emission for the five years would be 67 t CO_2e. Implementing this recommendation the District Office and provincial clinics will reduce the CO_2e emissions by 408 t CO_2e (475 -67 t CO_2e) for the next five years.

6.4.4 Reducing printing paper

Ekurhuleni Health District Office and provincial clinics used 7540 boxes of A4 printing paper from January 2010 to December 2014. The carbon emissions from office paper accounts for 1% of the total carbon footprint of the district, emitting 181 t CO_2e. Office paper is used for different purposes at the District Office, such as for reports, minutes of meetings, agendas for meetings, official memo communication, certificates, etc. It is important for the District Office to take measures to reduce office paper consumption and its associated carbon footprint. The following steps can be considered by employees to reduce their carbon footprints, as suggested by Harack (2010).

- Written documents (reports) should be reviewed in Microsoft Word by tracking changes rather than printing the documents and reviewing it.
- Before printing reports or documents carefully proof read it thoroughly. This will avoid the unnecessary printing of documents.
- Avoid printing minutes of the previous meeting. Use a projector to display the minutes of the meeting.
- Use the electronic storage system to file documents and reports instead of printing and archiving the documents.
- If printing cannot be avoided, then print on both sides of the paper.
- When printing information from the internet, copy and paste the information to word documents before printing. This will reduce unnecessary printing of information from the website.

6.5 GENERATING REVENUE BY REGISTERING A CLEAN DEVELOPMENT MECHANISM PROJECT

Clean Development Mechanism (CDM) was initiated under the Kyoto Protocol. The CDM allows organisations or companies in the developed countries to invest in projects, usually in the developing countries, to meet their carbon emission reducing goals. In return, the organisations or companies in the developed countries receive certified emission reduction (CER) points. In 2007, the CER was approximately $10 for every one t CO2e reduced (Winker & Van Es, 2007:29). The CDM project should focus on areas that will allow the change to move into a low carbon economy.

Therefore, the Treasury Department has encouraged projects from the following areas, energy and energy efficiency, transport, agriculture, forestry and other land use and waste (National Treasury, 2014:20). In the South African context, the cost per ton for the reduction of carbon dioxide equivalent is R120 (National Treasury. 2013:15). Based on the emission reducing opportunities revealed in this study, the District Office and provincial clinics could possibility qualify for CDM project register for CER points.

6.6 CONCLUSIONS

Climate change remains a global problem. The effects of climate change are well documented worldwide and developing countries are more at risk due to limited financial resources to take adaptive measures. South Africa as a developing country is at risk of the negative effects of climate change in different sectors, including the health sector. Therefore, Ekurhuleni Health District as a health sector should consider its contribution to reduce greenhouse gases emissions, in the light of improving the health of their constituent. With this in mind, this study had three objectives that will be discussed.

6.6.1 Objective 1

The first objective of the study was to estimate the carbon dioxide equivalent emissions of Ekurhuleni Health District Office and provincial clinics. In order the meet this objective, a quantitative study design was used to quantify the carbon dioxide equivalent emissions from different carbon emission variable sources, such as government fleet vehicles, Information and Communication Technology (ICT), air conditioners and office paper. Data was collected from different sources, such as the Transport Department, the Information Technology Department, a Physical Assessment and the Procurement Department respectively. The research methodology included the international guidelines in calculating the carbon footprints of organisations or companies, namely Greenhouse Gas Protocol and Department of Environmental Forest and Rural Affairs (DEFRA).

The results of the study in terms of the carbon equivalent emissions from January 2010 to December 2014 showed that the highest CO_2 emissions was from electricity 35150 t CO_2e (92%), followed by vehicles emitting 1362 t CO_2e (4%), ICT 862 t CO_2e (2%), air conditioners emitting 475 t CO_2e (1%) and emissions from office paper being 181 t CO_2e (1%). The carbon emissions were categorised into three scopes, namely Scope 1 emissions (government vehicles), Scope 2 (electricity consumption) and Scope 3 emissions (ICT, office paper and air conditioners).

6.6.2 Objective 2

Qualitative research design was used to meet the second objective of the study, which was to determine the knowledge and perceptions of climate change among managers and operational employees in the District Office and provincial clinics. Face-to-face interviews were conducted in which 33 participants were interviewed from management and operational employees. The research participants were selected using purposive sampling methods. The interviews were tape recorded, transcribed, analysed using content analysis methods and identifying the underlying latent themes.

Table 6.6 **Main findings of knowledge of climate change among employees**

Managers (n=10)		**Operational employees (n=23)**	
% have knowledge	% lack knowledge	% have knowledge	% lack knowledge
What is your understanding of climate change?			
100%	0%	87%	13%
In your opinion, what do you think are the causes of climate change?			
70%	30%	87%	13%
In your opinion, what are the consequences of climate change?			
100%	0%	100%	0%
What is your view on Greenhouse Gases (GHGs)?			
30%	70%	30%	70%

A total of 33 employees were interviewed consisting of 10 (30%) managers and 23 (70%) operational employees. The employees were asked two demographic related questions and nine research questions, of which four questions determined the knowledge of climate change. The responses to the questions are summaries in Table 6.6. The majority of the employees had basic knowledge on climate change, where 100% of the employees knew about possible consequences of climate change (direct and/or indirect). This may be attributed to the climate change affecting every part of their life. However, most employees were not knowledgeable about the concept of greenhouse gases (GHGs), which may be ascribed to the word "green" that causes confusion and misconception, because the colour green is regarded as an environmental friendly colour. Therefore, it is recommended that employees be trained or informed about GHGs.

Table 6.7 **Main findings of perception of climate change among employees**

Managers (n=10)		**Operational employees (n=23)**	
% Yes	% No / other	% Yes	% No / other
Climate change will have an impact on job description			
70%	30%	78%	22%
Climate change viewed as an important factor			
90%	10%	65%	35%
Concern about future of the planet and climate change			
90%	10%	91%	9%

Five (5) questions assessed employee's perceptions to climate change. Table 6.7 shows the responses of employees regarding three (3) questions. It can be seen that the majority of employees are concerned about the future of the planet and climate change and believed that climate change will impact their job description. The response regarding the impact of COP 17 in South Africa is shown in Table 6.8.

Table 6.8 **Perceptions of the impact of COP 17 in South Africa.**

What is your opinion about COP 17 held in Durban? Do you think it will have an impact in South Africa?							
Managers (n=10)				**Operational employees (n=23)**			
+VE impact	No impact	Not aware of COP 17	Other	+VE impact	No impact	Not aware of COP17	Other
40%	20%	20%	20%	43%	9%	30%	18%

+VE = Positive

The majority of employees were optimistic about the impact of COP 17 in South Africa. The participants highlighted that the success of COP 17 in South African context lies in the implementation of the decisions made during the conference. However, it is also important to note that some employees were not aware of COP 17. This highlights the need to raise public awareness in climate change issues via other means. The last question covered the employees suggestions on ways the District Office and provincial clinics can avoid climate change. The following measures were highlighted, switching off lights and appliances at night in clinics, saving energy, the installation of solar panels, the planting of trees, the implementation of electronic systems to reduce paper consumption, using bicycles instead of vehicles and water and waste controls.

6.6.3 Objective 3

Lastly, the third objective of the study was to identify potential mitigation strategies to reduce carbon emissions. The following recommendations can be made:

Scope 1 Direct emissions: Government fleet vehicles

(1) Hybrid vehicles; and

(2) Electrical vehicles.

Scope 2 Indirect emissions: Purchased electricity for facilities

(1) Solar panels;

(2) Solar geysers; and

(3) Motion sensor and fluorescent light bulbs.

Scope 3 Indirect emissions: Office paper, ICT and air conditioners

(1) Substituting personal desktops with laptops;

(2) Power saving options;

(3) Substituting HFC-23 air conditioner refrigerant with R410A;

(4) Reducing printing papers; and

(5) Generate revenue by registering for CDM projects.

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APPENDIX A

University of South Africa (UNISA) ethics clearance

UNISA university of south africa

2013-10-25

Ref. Nr.: 2013/CAES/030

To:
Student: IO Elimi **Student nr: 50829319**
Supervisor: Prof H Stoffberg
Department of Environmental Science
College of Agriculture and Environmental Sciences

Dear Prof Stoffberg and Mr Elimi

Request for Ethical approval for the following research project:

An estimate of carbon footprint of Ekurhuleni health district and provincial clinic employees

The application for ethical clearance in respect of the above mentioned research has been reviewed by the Research Ethics Review Committee of the College of Agriculture and Environmental Sciences, Unisa. Ethics clearance for the above mentioned project (Ref. Nr.: 2013/CAES/030) **is approved** after careful consideration of all documentation submitted to the CAES Ethics committee. Approval is granted for the duration of the study.

Please be advised that the committee needs to be informed should any part of the research methodology as outlined in the Ethics application (Ref. Nr.: 2013/CAES/030), change in any way. In this instance a memo should be submitted to the Ethics Committee in which the changes are identified and fully explained.

The Ethics Committee wishes you all the best with this research undertaking.

Kind regards,

Prof E Kempen,
CAES Ethics Review Committee Chair

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsmile: +27 429 12 429 4150
www.unisa.ac.za

APPENDIX B

Ekurhuleni ethics clearance

Ekurhuleni
METROPOLITAN MUNICIPALITY

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

RESEARCH ETHICS CLEARANCE CERTIFICATE

Research Project Title: An estimate of Carbon footprint of Ekurhuleni Health District, Provincial clinics and their employees.

Research Project Number: 19-09-2013-01

Name of Researcher(s): Mr. Ibrahim O Elimi

Division/Institution/Company: University Of South Africa

DECISION TAKEN BY THE EKURHULENI HEALTH DISTRICT ETHICS PANEL (EHDEP)

- *THIS DOCUMENT CERTIFIES THAT THE ABOVE RESEARCH PROJECT HAS BEEN FULLY APPROVED BY THE EHDEP. THE RESEARCHER(S) MAY THEREFORE COMMENCE WITH THE INTENDED RESEARCH PROJECT.*
- *NOTE THAT THE RESEARCHER WILL BE EXPECTED TO PRESENT THE RESEARCH FINDINGS OF THE PROPOSED RESEARCH PROJECT AT THE ANNUAL EKURHULENI RESEARCH CONFERENCE HELD IN JULY/AUGUST.*
- *THE ETHICS PANEL WISHES THE RESEARCHER(S) THE BEST OF SUCCESS.*

Dr Joseph Sepuya

DEPUTY CHAIRPERSON: EKURHULENI METROPOLITAN MUNICIPALITY

Dated: 08/10/2013

Dr. R. Kellerman

CHAIRPERSON: GAUTENG DEPARTMENT OF HEALTH (EKURHULENI REGION)

Dated: 17/10/2013

APPENDIX C

Permission for data collection

15.2-APPENDIX B: LETTER TO OBTAIN PERMISSION TO ACCESS DATA

Mr.Ibrahim O.Elimi
Environmental Health Practitioner
Ekurhuleni Health District
Villa Heidi, Germiston
1400

Ms. N. Mekgwe
Chief Director: Ekurhuleni Health Services
Villa Heidi
Germiston
1400

Dear Madam.

RE: REQUEST FOR PERMISSION TO ACCESS DATA

My name is Mr. Ibrahim O. Elimi an Environmental Health Practitioner (EHP) working in Ekurhuleni Health District office and a part time postgraduate student in University of South Africa (UNISA). I plan to carry out a research project to estimate the carbon footprint of Ekurhuleni Health District and provincial clinics employees.

The benefits of the study are the following:

- Scientific evidence has proven that climate change is detrimental to the health sector; moreover it is the responsibility of the global community, government and individual to provide urgent remedial actions to address climate change. Therefore Ekurhuleni Health District as an organ of state is accountable for its contribution of carbon emissions. Considering this it is imperative for Ekurhuleni Health District to implement measures to combat climate change. However before any measures can be implemented it's crucial to understand the current greenhouse gas (GHG) emissions being produced. Therefore this study will investigate and quantify the carbon dioxide equivalent emissions produced by Ekurhuleni Health District and its employees; furthermore a baseline GHG emission will be formed.
- in the light of the national climate change response green and white paper requirements, the former denote that in order to lessen the greenhouse gas in the atmosphere the polluter pay principal should be implemented , this entails that the polluter is financially accountable for the remedial cost for harming the environment. The latter states that each

sector or subsector will be required to set emission reduction levels and develop plans to achieve these levels. Therefore, this study will assist Ekurhuleni Health District in planning climate change response strategies and developing policy towards climate change mitigation measures.

- Conducting this study will identify challenging areas within the district with the highest carbon emissions and formulate potential mitigation strategies to reduce these emissions.
- This study will establish climate change perception of employees thereafter, create awareness on carbon footprints and educate employees on different methodology of reducing their carbon emissions.

Considering the above benefits of the study, permission to access and analyse primary data is required. These data includes (a) government fleet vehicles (kilometer travelled and total fuel consumed), (B) Electricity bills from the clinics and district office, (C) the amount of printing paper used and greenhouse gas emissions asociated with Information and Communication Technology (ICT) equipments available (computers & cell phones). Furthermore, the study also determines the perception of climate change among employees.

For further details on the study please refer to the attached document to the letter. I am hoping to commence with the data collection and interviews between 01 December 2013 - 30 April 2014. Ekurhuleni Research Committee have approved the research project (see attached document)

I look forward for your favourable consideration.

APPROVED/~~NOT APPROVED/AS AMENDED~~

Signature: MMekgwe   Date: 23/10/2013

Ms.N. Mekgwe: Chief Director Ekurhuleni Health District

APPENDIX D

Interview guide (questionnaires)

Section A: Demography

Q1: What is your designated occupation?

Q2: What is your designated title?

Section B: General Questions

Q1: What do you understand about climate change?

Q2: In your opinion, what do you think causes climate change?

Q3: In your opinion, what are the consequences of climate change in general?

Q4: What is your opinion about Greenhouse gases?

Q5: How important is climate change to you?

Q6: How would climate change affect your job description?

Q7: What is your opinion about COP 17 held in Durban? Do you think it will have an impact in South Africa?

Q8: Is there a way on how the clinics or the District Office can reduce climate change?

Q9: Do you have a concern about the future of the planet and climate change?

APPENDIX E

Consent form

UNISA university of south africa

15-APPENDIX

15.1-APPENDIX A: CONSENT FORM

CONSENT FORM

TITLE OF RESEARCH PROJECT

AN ESTIMATE OF CARBON FOOTPRINT OF EKURHULENI HEALTH DISTRICT AND PROVINCIAL CLINICS EMPLOYEES

Dear Mr/Mrs/Miss/Ms ______________________________ Date...../...../20...

NATURE AND PURPOSE OF THE STUDY

The Purpose of the study is to estimate the carbon footprints of Ekurhuleni Health District, Provincial clinics and their employees. This involves obtaining access and analysing primary greenhouse gas emissions related data such as: (a) government fleet vehicles emissions (kilometer travelled and total fuel consumed), (B) Electricity bills from the clinics and district office, (C) the amount of printing paper used as well as greenhouse gas emissions data related to Information and Communication Technology (ICT) equipments available (computers & cell phones). Furthermore, the study also determines the perception of climate change among employees.

RESEARCH PROCESS

1. Your voluntary participation is required in the study in a form of an interview.
2. The interview will be lead by the researcher and it will take 30 minutes to complete.
3. The venue of the interview will be at your place of employment (clinic or district office).
4. Structured open ended questions will be asked to determine your perception of climate change.
5. Basic demographic questions will also be required from you
6. There is no right or wrong answers.
7. Assistance in clarifying any questions asked by the researcher will be provided.
8. All the opinions obtained from the interview will be used to determine the overall perception of climate change.

NOTIFICATION THAT PHOTOGRAPHIC MATERIAL, TAPE RECORDINGS, AND A MEASURING TAPE OR MECHANISMS WILL BE REQUIRED

A tape recording device will be used to record the interview. The aim of recording the interview is to assist the research in capturing varies opinions relating to perception of climate change and being able to review the information in more details, furthermore the recorded materials will be transcribed. However if the participant is not comfortable with the recording the interview only notes will be taken.

Photographs of the infrastructure (buildings) of provincial clinics and district office will be taken; this will be done at the place of employment of participant, after the interview. The aim of taking these pictures is to give the readers an image and an idea of what types of building were assessed for carbon footprints furthermore; The photos will be stored under lock and key at the researcher's residence, pending the publishing of dissertation and scientific papers. **The photographs will not include people.**

CONFIDENTIALITY

The opinions obtained during the interview will be kept confidential and only the researcher will have access to the information. No data published in dissertation and journals will contain any information through which interview participant may be identified. Your anonymity is therefore ensured. Furthermore, the building photographs will not include any person.

WITHDRAWAL CLAUSE

I understand that I may withdraw from the interview at any time. I therefore participate voluntarily until such time as I request otherwise.

POTENTIAL BENEFITS OF THE STUDY

- Scientific evidence has proven that climate change is detrimental to the health sector; moreover it is the responsibility of the global community, government and individual to provide urgent remedial actions to address climate change. Therefore Ekurhuleni Health District as an organ of state is accountable for its contribution of carbon emission considering this, its imperative for Ekurhuleni Health District to implement measures to combat climate change. However before any measures can be implemented it's crucial to understand the current greenhouse gas (GHG) emissions being produced. Therefore this study will investigate and quantify the carbon dioxide equivalent emissions produced by Ekurhuleni Health District and its employees; furthermore a baseline GHG emission will be formed.
- In the light of the national climate change response green paper requirements, which states that each sector or subsector will be required to set and emission reduction level and develop plan to achieve this levels, this study will assist Ekurhuleni Health District in planning climate change response strategies and developing policy towards climate change mitigation measures.
- Conducting this study will identify challenging areas within the district with the highest carbon emissions and formulate potential mitigation strategies to reduce these emissions.
- This study will establish climate change perception of employees thereafter, create awareness on carbon footprints and educate employees on different methodology of reducing their carbon emissions.

INFORMATION (contact information of your supervisor)

If I have any questions concerning the study, I may contact the supervisor, Prof Hennie Stoffberg, at the Department of Environmental Science, Florida Campus, UNISA, Tel: 011 471 3386.

CONSENT

I, the undersigned, ... (full name) have read the above information relating to the project and have also heard the verbal version, and declare that I understand it. I have been afforded the opportunity to discuss relevant aspects of the project with the project leader, and hereby declare that I agree voluntarily to participate in the project.

I indemnify the university and any employee or student of the university against any liability that I may incur during the course of the project.

I further undertake to make no claim against the university in respect of damages to my personal or reputation that may incurred as a result of the project/trial or through the fault of other participants, unless resulting from negligence on the part of the university, its employees or students.

I have received a signed copy of this consent form.

Signature of participant: ....

Signed at...

Witnesses

1 ....

2 ....